PAPERS

ON SUBJECTS CONNECTED WITH

THE DUTIES

OF THE

CORPS OF ROYAL ENGINEERS.

R. E.

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INTRODUCTION.

THE delay that has occurred in the publication of the second volume of Professional Memoranda, has been principally caused by the number and character of the papers contributed; and the same cause has operated to enlarge the bulk of the volume, not only beyond that published last year, but also beyond what the number of subscribers and the moderate amount of the annual payment would altogether justify. The success, however, which has attended the publication of the first volume, and the prospect of an increasing number of subscribers as the work continues, and its enlarged professional character becomes more developed, has determined me not to postpone the publication of any of the papers which now form this volume, although the effect will be to oblige me to draw to some extent upon the subscription for the year 1838. The amount of this anticipation I trust, however, to cover by the increased sale of the work. Should this not be the case, and should the narrowness of the publication-fund oblige me to reduce the size of the next volume, the interesting nature of the various papers here given must plead my excuse.

To Officers of Engineers, the Memoir on the Fortifications of Western Germany is of paramount interest. It explains the modifications which have been introduced by the Prussians and Austrians in the general outline of their works, and gives much valuable information as to the details: and on this subject I feel that I cannot confer a greater service on my brother Officers, than by quoting the following remarks of Lieut.-Colonel Reid.

"If we sit down satisfied that the art of fortification, and the rule of construction in that art, as laid down by Vauban and Cormontaigne, are perfect and sufficient, we shall assuredly be left behind in the race of improvement by the other great nations who are at the present moment turning all their attention to the modifications in the art of defence, which alterations in the system of warfare, and the greater power of the various weapons employed, have rendered necessary.

" It is not a sufficient reason, that the principles of defensive fortification should remain unstudied in England, because we have no great internal fortresses, and because we rely on our maritime superiority. We have colonies to defend; we have our naval arsenals to protect; which, while an object of great importance, is rendered more difficult than ever from the extended application of steam power to shipping generally.

" As our fortifications are limited, and we have not, as other nations, specimens of the defensive art constantly before us, it is more especially necessary that the *principles* upon which they are constructed should be perfectly understood. We are too apt to follow servilely the rules dogmatically laid down in the published works on the art of fortification, while our business should be, to apply the general principles of the art to a species of fortification suited to the circumstances of our country.

" In the smaller description of forts required for the defence of harbours and colonies, all the true principles of defence must be kept in view; whilst at the same time it is necessary to adapt their size to small garrisons at all times, whether of peace or war, so that they may not be found cumbrous to the country.

" It is therefore not alone among the regular fortifications of the French, and in the school of Vauban, that we should study; in all parts of the world ingenious constructions are to be met with; instances of the most skilful adaptations of general principles to the ever-varying features of the ground. If officers then who travel would record what they see bearing on this subject, the facts thus collected would form an invaluable body of examples for our guidance.

" Few countries afford so many opportunities of studying the art of defence (particularly when applied to irregular ground) as Spain, owing to the many and long protracted wars of which it has been in all ages the theatre: descriptions of the varied forts of that country would therefore be of great value to us.

" Among the works executing by the French, Lyons is of the greatest importance: it is considered as the great strategical point for the defence of the South of France; and they are there forming what they term a ' permanent entrenched camp,' consisting of reveted detached works, each defensible by itself. The details of every one of these works seem to have received the utmost consideration, and there appears something original in each. We advocate examination into these and similar new constructions, not in the spirit of *spying*, but with the higher view of cultivating and extending the knowledge of the art

of defence, which it is the true interest of every nation to improve. As England throws open her fortresses to the inspection of foreigners, we have no doubt but that, on proper application through our Ministers at foreign Courts, facility would be given to Engineers and other officers of witnessing the improvements adopted by other nations.

" The Austrians are preparing a great fortress of support at Verona, for the defence of their Italian territories: there it is said the bastion system, with long lines of defence applicable to the range of cannon, is combined with towers placed at short intervals from each other, suitable to the short range of musketry. These towers serve the important purpose of keeps, and remedy one of the greatest defects of modern fortification. It would be highly desirable therefore to gain some information regarding the new works at Verona.

" Bayonne is intended to be made one of the greatest fortresses in Europe, and to give protection to an army of 60,000 men. This was a project ordered by Napoleon, and the plans were approved of during his reign: they are now being carried into execution by small portions annually. In these new works, it is understood far greater facilities are afforded to the troops occupying them to act offensively than in Vauban's systems, where they are too often compelled to defile from narrow sally-ports close to their enemies, without the possibility of taking the proper order of battle to meet them.

" The defence of the mouths of our harbours is a point of paramount importance; and it is incumbent on us, as Officers of Engineers, to devote particular attention to the subject. Here also we should endeavour to learn what precautions other nations are adopting to meet the changes taking place in the system of war. We may instance Newport, in the State of Rhode Island, a great naval station of the Americans, as an important position now being fortified.

" The question of the best construction of booms, and other impediments to prevent steam vessels from forcing the mouths of harbours, requires study and consideration; for there cannot be a doubt but that at the outbreak of another war, fire-ships, moved by steam, will be extensively used."

It is not, however, only on the subject of the construction of the different systems of fortification that information is desirable; the interior arrangements for the accommodation of the garrisons, hospitals for the sick, magazines for provisions and military stores, have a very great influence on the duration of a

siege. A paper, showing the requisite amount and description of bomb proof accommodation in a fortress of a given size, first under the supposition that it contains only its ordinary garrison, and secondly, that it is made a place of depôt for different description of stores (either naval or military, according to position), would be a valuable contribution.

The attention of officers should be drawn to the various details of military equipment. Colonel Reid has touched upon this matter in the first paper in this volume; and I have reprinted a note from Colonel Jones's 'Sieges in the Peninsula' upon the same subject. The construction of the various tools, the proportion they should bear to each other according to the nature of the service, the best mode of packing according to the character of the conveyance; all these require attention. The labours of Colonel Pasley, Colonel Blanshard, and Sir James Colleton, have placed our pontoon equipment in a satisfactory state; and I trust, in the next volume, to be able to give an account of the different forms of pontoon proposed by these officers, and of their application to the construction of military bridges.

The paper on the subject of Hurricanes, by Colonel Reid, will be read with great interest, and I trust will induce many to turn their attention to atmospheric phenomena generally. The observations of greatest interest at present are those for the purpose of determining the phenomena of terrestrial magnetism. The Royal Society have obtained from the government a sum of money for the purchase of the necessary instruments; and they have expressed their willingness to confide these instruments, with full instructions for their use and application, to the Officers of Engineers at the different stations where it is desirable that experiments should be made. To this confidence I feel certain we shall respond; and I hope shortly to be able to procure from the Society both the instruments and instructions necessary to enable us to commence our observations.

Since the publication of the first volume, an 'Aide Mémoire à l'Usage des Officiers du Génie,' has been published at Paris, by Captain Laisné, of the French Engineers. The arrangement of this work is very good, and may serve in some measure as a model for us when we commence a work of the kind. Portions of this will admit of translation, with the mere change of weights and dimensions from the French to the English standard; and any officer who has time and opportunity will be usefully employed in selecting and translating such passages.

The following is the Statement of Receipts and Expenditure laid before the General Meeting on the 1st of February, 1838.

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Balance	176	8	9				
	381	0	0		381	0	0

Since February several of the remaining copies of the first volume have been sold, and various officers have attached their names to the list of subscribers. I have received assurance of the intention of the Officers of the E. I. C. Engineers to afford us their assistance and support; and from the nature of the duties upon which they are employed, we may expect to receive from them some valuable communications. I trust, therefore, that the list of subscribers hereto annexed will be largely increased; and that next year I shall be able to present as satisfactory a statement to my brother Officers as I was able to do at the last meeting.

W. DENISON,
Lieutenant, Royal Engineers.

ROUGH SKETCH OF THE COUNTRY
between the
AGUEDA AND THE COA.

PROFESSIONAL PAPERS.

I.—*On Intrenchments as Supports in Battle, and on the Necessity of Completing the Military Organisation of the Royal Engineers. By Lieutenant-Colonel* REID, *Royal Engineers.*

THE annexed plan of the battle of Fuentes d'Onoro, was made very soon after that action was fought in 1811. The intrenchments thrown up on the field, whilst the two armies were still in presence of each other, were drawn upon the spot, and inserted on the plan at the time with great care. The troops were marked upon it, with the assistance of an officer who commanded a brigade in the action; and after an attentive perusal of the dispatches of both generals commanding the armies.

It might have been sufficient simply to print the plan itself, which, from having been carefully made, is alone of some value; but the object of the present article, is mainly to press the importance of Field Intrenchments to the army; and the advantage of possessing such a field equipment as to enable us in war, to avail ourselves of the great support given by intrenchments. The very slight works thrown up at Fuentes d'Onoro had a great influence, if we may judge by the French general's despatch; and therefore, slight as they were, they deserve notice.

An animated account of the battle will be found in Napier's History. The following concise description of the affair, and of the ground where it was fought, will be sufficient for this place. It was risked to prevent the French from revictualling the fortress of Almeida on the frontiers of Portugal, when they retreated out of that kingdom in 1810.

Almeida lies between the Agueda and the Coa, two rapid rivers, both of which are branches of the Douro. As they approach their confluence with it, their banks become very precipitous; and it is difficult to scramble across their rocky beds, even when the water is so low that they might be otherwise fordable. A small map of the country between these two rivers is annexed.

The two little brooks, Duas Casas and Turon, running nearly parallel to the Coa, form vallies on a small scale much resembling those of the Coa and Agueda. Near their sources, infantry may pass in all directions, but cavalry are impeded by deep holes in the rocky beds of the brooks, excepting just at the spot where they take their source. Lower down the streams the vallies become broad and deep, and the slopes of their sides are covered with many massive isolated rocks. The ridge between these vallies was without inclosures. Slight ravines descend from it on both sides, some rocky like the vallies themselves, but others scarcely marked enough to afford shelter for troops against an enemy's cannon.

The village of Fuentes d'Onoro is situated at that part of the valley of the Duas Casas where a marked change first takes places in the features of the ground; for thereabouts, those isolated rocks begin, which form a military obstacle. The village lies on the Portuguese side of the valley, and is so situated as to be much exposed to the fire of an enemy's cannon from the other side. The houses lie scattered, and are not substantially built; but there are many small gardens, surrounded by thick dry stone walls, affording ample materials for barricading. The greater part of the village lies in the bottom of the valley, but a portion of it extends up to the plateau, on which the British and Portuguese took post.

The cavalry being in advance, supported by the light division of infantry, observed the enemy coming out of Ciudad Rodrigo, and passing its bridge on the 2nd of May, 1811. The French directed their march towards Almeida, and the light division fell back on Fuentes d'Onoro. The plan shows, in a general way, the position of the armies when they came in presence of each other on the 3rd of May, 1811, the corps moved during the action, having first occupied the dotted position. The chief force of the English and Portuguse was behind Fuentes d'Onoro; but divisions in observation were extended as far as the ruins of Fort Conception, about four or five miles from the main body at Fuentes d'Onoro.

It was very desirable that the communication by Sabugal should be kept open as long as possible; being the natural connexion with the right of the army then operating south of the Tagus. For this reason, a guerilla corps of Spanish cavalry and infantry was posted on a remarkable woody height, about a mile and a half to the right of Fuentes d'Onoro; in which height the Duas Casas brook has its source, formed by several heads, near Nave d'Aver. The only passage of

the Coa, immediately behind the position, was by the Bridge of Castello Bom, and by a very rocky bad road leading down to the bridge.

Eight light infantry battalions of British infantry were posted in the village of Fuentes d'Onoro; and the troops intended to support this point were somewhat retired on the plateau above the village. The nature of the ground indicated this point as an important one to hold firmly.

As the bridge of Castello Bom lies immediately behind Fuentes d'Onoro, the French general hoped, by carrying the village, and placing the main strength of his army on the plateau, to make a retreat by its bridge very dangerous, or impossible. The village was therefore resolutely attacked on the 3rd of May, and as valiantly defended. Taken and retaken, after a long and hard contest, the English remained in possession of the upper part, next their own position, whilst the French kept the houses in the bottom.

On the 4th of May, the armies were not engaged, or very partially so; for the French general spent the day looking how he could turn the British right; and in the night he began to carry his principal force to his left, in order to attack the right of the allied army.

The positions marked in the Plan, without dots, show sufficiently the dispositions made for this attack.

The 7th division had been sent on the evening of the 4th from near Fuentes d'Onoro, and took post behind the village of Poço Velho, in an open wood of the ilex oak, (which abounds there); and which movement was ordered with the view of covering the Sabugal communication if possible. When the French general's movements were seen next morning, the light division was marched to its right, to support the 7th; and this support soon became necessary; for the French army having 5000 cavalry against 1000, (besides being superior in infantry and artillery), the British right wing had to retire, and a new line was formed with the right thrown back, as indicated on the Plan; the 7th division and the Spaniards occupying the ground between the Turon and the Coa.

That the Plan might not be confused, the further movements of the French are not marked upon it. The direction of their march, in which they brought their left forward, outflanking the English right with their cavalry, cannot be mistaken. Instead, however, of continuing the attack, the French general paused, and the English during the following night made every exertion to strengthen their position, with such small means as they possessed.

It was understood that the trenches dug across the summit ridge were only

intended to cover the infantry from the fire of the enemy's cannon, which took great effect on that level ground. These lines had no ditches; the earth being dug and thrown forward, as in a siege approach. It was the custom during the late war, for the British infantry, when they occupied a defensive position, to draw up just behind and under cover of the slope of a ridge, when there was one, from whence the lines were brought forward to charge at the proper moment. There being no such cover across this summit, these trenches were to supply its place; and to preserve the usual formation of the troops, they should have been dug in straight lines, just where the troops were required to deploy. Formed like parallels at a siege, deployed infantry may sit down under cover, and rise, "elbows touching," in the best order to charge in line.

One of the greatest defects of intrenchments as they are often constructed is, that in occupying them, from being laid out in indented and flanking lines, the infantry must necessarily deviate from their usual order of battle. *Defensive positions are best maintained by offensive actions;* and defences, when it is possible, should be so constructed as to admit of the defenders coming forward in line, to meet and to attack in turn, the assailants. Indented defences have not the same objection when they are advanced in front of the main position, or line of battle, as all in front of the main position may be fought in skirmishing order. The trenches at Fuentes d'Onoro were however in the last position, beyond which there could be no retreat.

In the manner here advocated, part of the ground, which was a level plain, was taken up to be fortified after the battle of Toulouse in 1814; *i. e.* that part where the Paris road leaves the city; but there was this material difference between the environs of Toulouse and the barren country between the Turon and Duas Casas, that around Toulouse there were many substantial country seats. Strong country houses were fortified at about every 600 or 800 yards from each other, and each house garrisoned by half a battalion, who were never to have quitted their posts if attacked. These posts were completed; and in rear of the intervals straight trenches were just about to have been commenced when the enemy's army retired. The trenches were to have been made with slopes both in the front and rear, so easy of ascent that even cavalry might have passed over them; and they were solely intended to cover infantry against cannon, and to secure them in the best attitude for defending their ground by *offensive operations*. The fortified house nearest to the Paris road was to have had a brigade of mountain guns in the upper rooms, which were to have been fired from the windows, and nearly in enfilade of the road.

A position particularly well suited for being strengthened by fortifications was held by the centre of the Duke of Wellington's army in the winter of 1813.

The enemy possessed the fortress of Bayonne, at the confluence of the Nive with the Adour. The allied army was separated into three portions by the nature of the country: the right was beyond the Nive; the left near the sea at Biaritz, and the centre across a ridge, which, beginning near Bayonne, runs between the heads of the streams, which flow on one side to the sea, and on the other to the Nive. Two of these streams flowing in marshy ground, covered the flanks of this position and greatly contracted it; whilst across the summit ridge were found three good points of support, on ground somewhat more elevated than the rest; on the very centre stood the church of Arcangues, having a churchyard wall, flanked by the parsonage house; 300 yards on the right was the chateau of the seigneur, with garden-walls and outhouses, and 300 yards on the left a large brick farm-house. These three points were immediately fortified. There are two very distinct kinds of fortifications on a field of battle, *viz.* such as are intended to check an enemy, but from which the defenders may retire if pushed; and such as never should be abandoned. The three points alluded to were of the last kind. The reserves were placed in the upper stories; and if the defenders had been forced below, the troops were to have retreated up stairs and to have fired through the floors.

This ground had not been long occupied before the enemy attacked the allies; and the first attempt appeared to have been designed against this central position. The French army advanced along the summit ridge from Bayonne, bringing up their masses of infantry very near, and opening a battery of cannon at about 500 yards only from the church.

It deserves here to be recorded, that the outposts of the 52nd regiment had been so well fortified by a captain* of that regiment, that the pickets had no occasion to retire until they had fired their sixty rounds of ammunition. This officer had taught himself how to strengthen posts by barricades and other temporary expedients; and he deserved the support he always received from the engineers, who supplied him with what he required from their small depôt of intrenching tools.

The pickets being thus enabled to hold their ground, without risk, for a considerable time, the troops for the defence of the main central position had full

* The late Captain George Barlow.

time to assemble (for it was in December, and they were scattered in houses) and to deploy in the position, the greater part somewhat retired behind the slope of the ground. There was nothing in the defences which impeded the usual formation, and every thing was prepared to maintain this ground *offensively*.

The enemy not choosing to attack here, moved in the afternoon to their right, when the hard fought action at Biaritz ensued: and two days later they made an equally determined but unsuccessful attack with their whole force against the extreme right beyond the Nive.

Although the enemy's cannon were brought forward, and fired for a considerable time, at 500 yards distance from the houses, their eight-pounder shot did not once penetrate the walls. The infantry in the church-yard directed a heavy fire of musketry against the gunners, firing with elevation; and from the marks afterwards observed on the trees near where the enemy's artillery stood, the musketry must have had great effect.

Massena, who commanded the French army, speaking of the allies at Fuentes d'Onoro, states:—*

"The enemy passed the night (of the 5th) after the battle in intrenching strongly the summit of the level. They placed also epaulements in the ravines and behind the rocks. In short they barricaded the summits of the villages of Fuentes d'Onoro and Villa Formosa; drawing to their assistance all the resources of fortification against an attack by main force."

This description is overdrawn. It is true, that very formidable barricades had been raised in the upper portion of the village of Fuentes d'Onoro, and dry stone parapets amongst the rocks which flank it; and the troops who defended the village, no doubt, were inspired to work by two very hard days of combat, and a sense of their danger. The first division likewise formed obstacles in front of their new position, consisting of some trenches, and trap-holes to check the enemy's superior cavalry; and the 7th division had begun some barricades round the Atalaya, or ancient watch tower, beyond the Turon. But however much every man in that army, at that moment, might have been desirous of availing himself of "all the resources of fortification against an attack by main force," such was not within his reach; for it is supposed that this portion of the army had no other intrenching tools than the few carried by the regiments for other purposes; and there was but one engineer officer† present.

* *Times* Newspaper, 29th May, 1811.

† Lieut. Trench, soon after this killed by an explosion of gunpowder.

In the later campaigns of the Peninsular war, the engineer department carried a depôt of intrenching tools with each division of the army; small at first, but increased by degrees, until every division had 25 mule loads. In the Waterloo campaign the quantity carried was further greatly increased; but they were then carried in Flanders waggons, instead of on mules' backs.

The civil duties in which the military engineer corps has been almost exclusively engaged since the peace, have prevented that improvement in the Engineer Department generally, as a component part of the military service, which the officers composing the corps were enabled to give to it from the experience gained in the war: and in proof of what is here stated, it is sufficient to say, that we possess no pattern of an engineer field equipment in our arsenals. The military bridge equipment has been greatly improved, and has become a pattern sought after by all the other countries of Europe. Had the same pains been taken regarding the other parts of the engineer field equipment, there are no reasons why they might not have become equally complete.

Note No. 50, at the end of "Jones's Journal of Sieges," sets forth in strong terms the necessity of forming an Intrenching Establishment with horses and drivers; and in some notes prefixed to Colonel Pasley's Fortification, the same subject is again urged; and the proposal of having a section of drivers as an integral part of a company of sappers and miners is advocated.

We here recommend that 1000 intrenching tools be packed as best suited for war, and that the mode of doing so, be an exercise at the school of field instruction: that a part should be carried on pack saddles and the remainder in wheel carriages; but the most essential thing to be done is to horse them occasionally and to move them. The subdivisions should be complete in themselves, so that when a battalion or a brigade is detached in war, it may be enabled to receive a complete proportion of implements for fortifying itself in any post it may be required to occupy.

In peace, an engineer intrenching equipment might be marched to such drill grounds as afford space for exercises in field fortifications, such as are thrown up in haste on the field of battle; or it might sometimes be sent to the Military College, along with troops, and there, on Bagshot-heath, carry on practice on a better scale than is now done by a small party of the Royal Sappers and Miners, for the practical instruction of the cadets. Neither are such exercises only applicable to positions of defence. During the progress of an attack, there frequently occur points which it becomes of the last importance to maintain when gained. Villages

and groups of houses may become points of support for prosecuting an attack to a successful issue, if rapidly secured and barricaded; or they may save an attacking army from defeat: and sometimes it becomes of great consequence for troops who have taken a barricaded village, to know how to render the defences useless, or speedily to reverse them. This can only be done by old soldiers long accustomed to war, or else by young ones who have been properly instructed, and shown how it is to be done, before they are brought into action. It is not in the fortified posts of defensive positions only, that a corps trained as our Sappers and Miners now are, would be valuable, but also in supporting attacks and holding ground when gained.

Intrenchments on the field of battle would probably be much more used than they are, were it not for the system of modern armies, which leaves this part of war too exclusively to a single corps. The consequence is, that many officers rise to high commands without having considered the subject, and sometimes even believing the attainment of a knowledge in fortification to be difficult, and to require science beyond what they may possess.

That this wrong impression should be done away with is very important, both to the engineer corps and to the rest of the army: and it would be accomplished were the infantry of armies required to make intrenching, part of their military exercises; for the attention of the officers would be drawn to the subject in exercising their men; and they would soon learn that there is nothing mysterious or difficult to understand, in the field engineer's art.

It was proposed some years ago, and the proposal was approved and authorised, that all the infantry stationed at Chatham should take advantage, whilst quartered there, of the Engineer School of Field Instruction, so that every man might, once in his life at least, form a yard of common siege trench: and the advantage of this no one can doubt; certainly no officer will doubt it, who has had to lead soldiers, in a dark night, under an enemy's walls, after having given them a pick-axe in exchange for their musket, and had to direct them, in such a situation under fire, to make what they never saw or perhaps heard of before. The difficulties attending the extension and arrangement of a large body of untrained soldiers, under such circumstances, every military officer can appreciate.

The same authority allowed the regiments of infantry whilst at Chatham, to receive instruction in other important exercises connected with the duties of the engineers; and the distinguished conduct of the 13th regiment, in the assaults of

the Burmese stockades, may have been to a certain degree owing to the escalade, which they practised at Chatham, just before they embarked for India.

Highly valuable as this connection between the infantry and the military engineer school of practical instruction is to both, it is not sufficient; for the infantry soldier should be taught, whilst he is yet a recruit, that the construction of intrenchments is a part, and a very important part, of his military duty. Every recruit before being dismissed from drill, as fit to join the ranks, should, for this reason, be made to erect some small portion, as a yard, of breast-work; a very easy task; but which, if required to be done by authority, under their officers' guidance, would have the effect of causing intrenchments and their value, to receive in time due consideration.

That it would be desirable to instruct the infantry to a certain limited extent, in the construction and defence of intrenchments, is very generally admitted; and there can be no doubt, but that every well-disciplined army, like our own, would be still more formidable in the field, if thus instructed. That working wears out the clothes of soldiers is an objection which stands seriously in the way of such occupations, for it is true that it does destroy the clothing; and this is one part of the defective system to be corrected; for the fatigue or working dress has become unfit for its true purpose; by degrees it has been made a second neat dress, instead of one for work. By far the best fatigue dress is the old English frock, put on as our own peasantry wear it: and this some foreign nations have adopted, of blue colour with different facings. With such a dress over a soldier's clothing, he can work, or carry loads, without spoiling his clothes; and the same frock at night, when he has to lie out, helps to keep him both clean and warm. Whatever may be thought of it in peace, it is well suited for war.

By thus connecting still more intimately the exercises of the infantry with engineer duties in the field, the mode of applying field intrenchments to the support of contending armies would improve. It is susceptible of improvement; and the best school for the engineer to study it is amongst troops. Nor is all infantry to be strengthened by the same methods; for whilst well-trained infantry might maintain their ground best by having only strong points of support, amongst which they could act offensively, bad infantry might require many barricades, or almost continued lines. Whether redoubts or continued lines are to be preferred, therefore, will depend in some degree on the efficient state of troops defending them.

It is not intended here to enter upon any details of construction; yet it is

not out of place to remark, that no army can be complete in its code of field exercise, unless that code include rules and exercises for intrenchments in battle.

The rules and exercises for intrenchments are peculiarly a part of the exercise of the infantry; for when the engineers in the field are called upon to intrench a position, it is the infantry of the army who actually execute the works. A small publication, under the unassuming title of "Strengthening Outposts, in reference to the Duties of Officers in command of Pickets," perhaps comes nearer to what is required than any other published; but its author should not have called his subject a "threadbare one." It is one only beginning to reassume great importance. Discipline and tactics have now recovered what they lost in the middle ages, and field intrenchments will probably re-assume the same comparative importance in which they were held in ancient times; for modern improvements in projectiles, have not in any degree diminished the value of their support in battle.

The subject here discussed is not one suited to the present period of peace. Military exercises are now irksome, and military subjects tedious. The civil duties in which the Royal Engineers are engaged are, under present circumstances, far more interesting. But we must not forget that we are a component part of the army maintained for national defence; that the country in the late war suffered great losses from the imperfect state of the Engineer department; and that it is for the Members of the Corps themselves to show what is required to make them properly efficient.

There is no risk in our being less frequently or usefully employed in civil pursuits, by maintaining and improving our military system, and upholding our character as a military body; if we neglect this in the present day, the contrary probably would be the result.

NOTE

FROM

JONES'S "SIEGES."

It is a curious fact, that the superb expedition fitted out, regardless of expense, to effect an object dependant on the speedy reduction of the fortified places of Flushing, Bathz, Lillo, Liefkenshoek, and Antwerp, should have been sent from England, without any means whatever for bringing forward the engineers' stores, although some thousand horses were embarked for other purposes.

It is, however, proper to mention, in extenuation of this oversight, that, about a fortnight before the armament sailed, the Master General, on a pressing representation of the necessity of this service being attended to, ordered an equipment of one hundred horses, with drivers, to be transferred from the Artillery establishment, and embarked for the use of the engineers; but owing to some cause the order was never carried into effect. The consequence was a delay of at least three, if not four days in the reduction of Flushing; for if only fifty horses had been sent for the engineers' service with the left wing, the entrenching tools, &c. might have been landed on the Bree Sand, at the same time with the field brigades of guns, and have been brought up in sufficient quantities to have commenced operations against Flushing with vigour, on the night of the 1st of August, instead of the night of the 5th of August. It is altogether impossible to calculate the delay, or consequences which would have arisen from this want of carriage, had the tools and stores for the attack of Antwerp been forwarded by any considerable land movement, but, in all probability, they would have been fatal to the success of the enterprise.

It is not, however, at sieges only, that a horse-equipment for the conveyance of tools and stores would prove useful, but on every movement for offence or defence.

No one can doubt that the greater or less efficiency of an army depends on all its component branches, with their equipments, possessing corresponding powers of movement, so as to form altogether one complete body or machine. In this particular, no distinction can be made between cavalry, infantry, artillery, commissariat, or engineers.

But how stood the case on every expedition during the late war? With respect to the three first, it was so clearly evident that it would be useless to send troops into the field without ammunition, or artillery without guns, that a complete and well-organized establishment, of very great magnitude for those purposes, was invariably kept up in England, and a portion of it sent with every corps about to take the field.

Such establishments were also, on a smaller scale, kept up for the commissariat and hospitals; and on landing in an enemy's country, as the troops must be fed, and the wounded

removed, every means of transport which could be procured, was necessarily in the first instance added to their means.

The engineers, however, being totally unprovided with the skeleton of an equipment, could not be thus patched up; and no commander ever brought himself willingly to abstract from immediate and pressing services the drivers and horses necessary to create an entirely new establishment, till some misfortune, failure, or great emergency, rendered it imperative for safety, or that victory demanded it to secure her trophies.

It would be useless to recall the many instances in the early part of the last war, in which corps could not take advantage of various defensive expedients that presented themselves, such as destroying roads, blowing up bridges, retrenching posts, &c. from want of a field establishment of intrenching and miner's tools moving with them.

This deficiency of organization of the engineers' service, was so strongly felt by the Duke of Wellington in Spain, in 1811, that he fitted out a field-train depôt of 30 mules, which was successively increased to 50, 70, 80, and in 1813, to 120 mules, moving in a body. Subsequently, in 1814, this arrangement was modified into a proportion of 25 mules, marching with each division of the army; and the stores and tools they carried were found most highly serviceable on various occasions.

Napoleon, after the experience of nineteen years' incessant warfare, by a decree, dated 25th March, 1811, fixed the establishment of horses, waggons, and drivers, with their lading, for the engineers' department of the French army, as follows:—

Six troops of drivers for the field, and one in depôt: each troop for the field to consist of,

Men and Officers.	
Officers	3
Non-commissioned officers	5
Brigadiers	6
Trumpeters	2
Artificers	7
Privates	121

Horses.	
Draft horses	226
Spare horses	8
Riding horses	16
Total	250

Carriages.

Waggons with 4 horses, for intrenching tools	30
,, with 6 horses, for intrenching tools	4
,, with 4 horses, with bridge equipage	5
,, with 6 horses, with bridge equipage	5
Waggon with 4 horses, for miner's tools	1
,, with 4 horses, for petards and gunpowder	1
Forge carts with 6 horses	4

To convey 1,700 pickaxes, 170 miner's picks, 1,700 shovels, 1,700 long-handled shovels, total 5,270 intrenching tools; 680 felling axes, 4,020 bill hooks, total 1,700 cutting tools; and 8,318 kil. weight of machinery and stores. Every article was made to a particular pattern and weight, and each waggon had its particular lading assigned to it.

One troop formed part of each corps d'armée, and constantly moved with it, the same as its other equipments.

The foregoing is an example of splendid military organization, and is certainly far beyond that desirable or necessary for England to possess. Some engineers' carriage establishment ought, however, to be created; and we should steadily keep in view to improve the shape and manufacture of all our field stores, implements, and tools, so as to combine strength with lightness and portability. We should fix the relative proportions of each nature of article, of which given outfits of tools and stores ought to be composed, construct carts best adapted for their stowage and conveyance, apportion their lading and mode of packing, and decide on the proportions of tools and stores, in a certain number of carts, to accompany corps of different strength; so that, whenever a force shall embark for service, their field stores shall embark with them, as an organized equipment prepared to march as soon as landed and horsed.

It should be mentioned, that draft animals are far more readily to be procured in foreign and hostile countries than drivers, as corps of troops are frequently dispatched from England without any field equipment, in consequence of the nature and place of their operations being contingent on passing events. Such was the force sent under Sir J. Craig, in April 1805, first to Gibraltar, then to Malta, and ultimately, in December, to Naples. Immediately on landing, ample numbers of horses were purchased and allotted to the engineers; but although the stores were laden on carts, and prepared in every particular to march, they never could start for want of drivers, and such few articles as reached the frontier were forwarded by water-carriage to Gaeta. No one can possibly doubt the superior confidence to be reposed in a disciplined soldier over a foreign peasant, when acting as a driver for the first time under fire; and these considerations united, seem to point out drivers as being more essential to the efficiency of the department than even horses, and that a certain number should be embarked with every equipment of stores.

This object might possibly be attained without any additional expense, by enlisting a certain portion of each company of sappers to act as drivers, from men accustomed to carting work in the country. Being a good driver would not interfere with being a skilful sapper. Indeed men of that class are generally the most handy with the pick and shovel.

In Spain, mule carriage was undoubtedly a principal cause of the efficiency of the army. The commissariat and stores, by that means of transport, became as moveable as the troops; and it should be mentioned, in justice to the Spanish muleteers, that after the first campaign, they felt as confident, and moved forward, or to the rear, with as much order and coolness, on the eve of and during an action, as when the army was not in presence of an enemy. Such mode of conveyance will therefore, in all probability, be again resorted to, whenever the Peninsula becomes the scene of hostilities; and that the experience of the past war may not be lost, the following proportions of stores, tools, &c. drawn out in Spain, after some years' experience, as being those best adapted for given numbers of mules, are here inserted.

On future services, as the tools to be carried will be lighter, the number of each article for similar means of carriage will be increased.

List of a Field Equipment of Engineers' Stores for various Numbers of Mules.

INTRENCHING TOOLS.	Proportion for an Equipment of Mules.					
	100	50	30	25	20	12
Pickaxes	496	248	160	144	128	96
Spades	100	50	38	38	30	22
Shovels	404	202	158	130	124	90
Spare helves { Pickaxe	240	120	60	40	40	20
Spare helves { Shovels	240	120	60	40	40	20
MINER'S TOOLS.						
Miner's picks	10	4	3	2	2	..
Ditto pointed shovels	10	4	3	2	2	..
Jumpers	6	2	1	1	1	..
Borers { 2 feet	2	2	1	1	1	..
Borers { 1½ do.	1	1	1	1	..	..
Borers { 1 do.	1	1	1	1	1	..
Jumping bars	2	2	1	1	1	..
Miner's sledge hammers	6	2	2	1	1	1
Crow bars { 5½ feet	3	1	1	1	1	..
Crow bars { 4½ do.	4	2	2	1	..	1
Sand bags, bushel	600	240	..	..	..	..
Hand hammers { Large	2	2	1	1	1	..
Hand hammers { Small	2	2	1	1	1	..
Gads { 1st size	2	2	1	1	1	..
Gads { 2nd do.	2	2	1	1	1	..
Gads { 3rd do.	2	2	1	1	1	..
Scrapers	3	3	2	2	2	..
Needles	3	3	2	2	2	..
Wedges	2	2	1	1	1	..
MASON'S TOOLS.						
Mason's hammers	18	9	8	6	4	2
Wood mallets	2	2	..	..	..	..
Trowels	6	6	..	..	..	..
Chisels, of sorts	20	20	..	..	..	..
Iron levels, with plumb bobs and lines	4	4	..	..	..	..
CARPENTER'S AND SAWYER'S TOOLS.						
Felling axes	54	17	22	15	10	7
Broad axes	11	6	8	5	3	1
Bill hooks	200	80	80	60	40	20
Hand saws	47	23	22	22	20	6
Grindstone, 16 in. draw, × 3½ in thickness	1	1	1	1	..	..
Spikes boxes	1	1½	1½	1½	15 lbs.	15 lbs.
Nails, of sorts, boxes	1	1½	1½	1½	15 lbs.	15 lbs.
Saws { Tenon	2	1	..	..	..	..
Saws { Turning	2	1	..	..	..	..
Files for { Pit saws	120	120	120	120	60	..
Files for { Cross-cut	36	36	36	36	18	..
Files for { Hand	24	12	12	12	12	12
Files for { Tenon	24	12	..	..	..	..
Setters { Pit saws	2	2	2	2	1	..
Setters { Cross-cut	1	1	1	1	1	..
Setters { Hand	2	2	2	2	1	1
Planes, double and single iron { Trying	2	1	..	..	..	..
Planes, double and single iron { Jack	2	1	1	1	1	..
Planes, double and single iron { Smoothing	2	1	1	1	..	..
Planes, double and single iron { Of sorts	4	2	2	2	2	..
Plow plane, with irons complete	1	..	..	..	..	..
Adzes	10	6	6	4	4	2
Gauges	2	2	2	2	2	..
Augers, of sizes	12	6	6	4	4	2
Drawing knives	4	2	2	1	1	1

List of Field Equipments, &c.—continued.

Carpenter's and Sawyer's Tools—*continued.*	Proportion for an Equipment of Mules.					
	100	50	30	25	20	12
Chisels { Mortice	6	3	3	2	2	..
Chisels { Firmer	12	6	6	2	2	..
Scribing gauges	6	3	3	2	2	..
Chalk lines and reels	7	6	6	6	2	2
Hammers { Claw	4	2	2	2	2	2
Hammers { Riveting	2	1	1	1	1	..
Oil stone	1	1	1	1	1	..
Rag stones	2	1	1	1	1	..
Two-foot rules	10	6	6	6	4	2
Pit saws	4	4	4	4	2	..
Cross-cut saws	2	2	2	2	2	..
Chalk lbs.	5	5	5	5	2	..
Gimlets { Spike	6	3	3	2	2	2
Gimlets { Common	18	9	9	4	4	4
SMITH'S TOOLS.						
Small pack-saddle forge	1	1	..	..	..	..
Anvil, small	1	1	..	..	..	..
Vice, large	1	1	..	..	..	..
Steelyards	1	1	..	..	..	..
Hammers { Sledge	1	1	..	..	..	..
Hammers { Hand	1	1	..	..	..	..
Hammers { Bench	1	1	..	..	..	..
Hammers { Lett	1	1	..	..	..	..
Pincers, pairs	1	1	..	..	..	..
Files { Flat	9	9	..	..	..	..
Files { ½ round	6	6	..	..	..	..
Files { Round	3	3	..	..	..	..
Tongs, of sorts	4	4	..	..	..	..
Slices	1	1	..	..	..	..
Pokers	1	1	..	..	..	..
Hand vices lbs.	1	1	..	..	..	..
Steel for repairing tools lbs.	40	40	10	10	10	10
Coals bushels.	50	50	..	..	..	..
VARIOUS STORES.						
Fascine chokers pairs.	32	8	..	..	8	10	4
Hambro' lines skeins.	16	9	8	8	10	4
Paints { White lead lbs.	5	2	2	2	..	..
Paints { Lead colour lbs.	10	5	5	5	..	..
Paints { Linseed oil pints.	4	2	2	2	..	..
Paints { Turpentine pints.	1	1	1	1	..	..
Paints { Brushes { Large	2	1	1	1	..	..
Paints { Brushes { Middling	3	2	2	2	..	..
Paints { Camel-hair pencils	12	4	4	4	..	..
Large blocks { Double	1	..	..	..	..	..
Large blocks { Treble	1	..	..	..	..	..
Rope { 2-inch tarred coils	1	1	1	1	1	..
Rope { 3-inch white, for tackle, small coils	1	..	..	..	..	..
Marquees { Captains'	1	..	..	..	..	..
Marquees { Subalterns'	1	1	..	..	..	..
Round tents	10	3	1	1	1	1
Handscrew jack, middling size	1	..	..	..	..	..
Sap forks	2	..	..	..	..	..
Saucisson, made up yards.	100	100	100	100	50	..
Canvas yards.	12	12	12	12	6	..
White tracing tape	3000	3000	3000	3000	1500	..
Needles { Sewing lb.	12	12	12	12	6	..
Needles { Packing	6	6	6	6	3	..
Coarse thread lbs.	1½	1½	1½	1½	1	..
Twine	3	3	3	3	1	..

N. B. No mules for carrying plans and official papers are included.

In the two first columns for 100 and for 50 mules, the stores requiring it are supposed to be secured in boxes.

In the third column, viz. for 30 mule loads, the felling and broad axes are supposed to be carried in tarpaulins or canvas bags, to save weight.

In the fourth column, viz. for 25 mules, the felling and broad axes, and bill-hooks, are carried in tarpaulins; with 20 mules, the handsaws also, and nails, spikes, and steel, are carried in tarpaulins. Under 20 mules there should be no boxes carried.

The above will serve to show the very trifling weight of a liberal engineers' field equipment. One hundred carts, drawn by one or two horses each, with one hundred drivers, would serve to move stores and tools sufficient for a large army;* and as 5,000 drivers, and 10,000 horses were kept on foot last war for the efficiency of the guns and ammunition, an establishment of two troops for the conveyance of stores and tools could not be deemed unreasonable, or an oppressive addition to the burdens of the country; particularly as the horses and drivers, when not in the field, might, with much utility and saving of expense, be employed on the public works, in lieu of contractors' horses and drivers.

* One-horse carts, even in hilly districts, constantly drew 15 or 18 cwt.; now, as a pickaxe weighs only 5 lbs., and a shovel only 4½ lbs., ten horses in ten carts would, under all circumstances, be able to move forward intrenching tools sufficient for the employment of 2,000 men. Such an establishment in Spain, to the amount of fifty carts, would, consequently, have converted positive deficiency of stores into absolute abundance at the several sieges.

Note.—There is great room for improvement in the general construction of most of the tools which were furnished to the Government by contract during the late war, and of which a great quantity are still on hand. Sir J. Jones mentions in one or two places, that the soldiers always preferred working with the French tools when they could be procured, as being lighter and easier to use in every way; but independent of the construction, the contract tools are in other respects inferior; the quality of the material of which they are composed is bad, and gross frauds were practised, owing to the want of sufficient attention to the examination of the stores when furnished. The axes were not steeled at the edge, or if they were, the quantity of steel was so trifling, that the first time the tool was ground the whole disappeared: the jumpers were made in the same way. In these two instances I speak from my own knowledge; I have little doubt that others equally glaring might be discovered.

ED.

Table showing the Quantities of Intrenching Tools which were provided for various Siege Operations, with the Quantities expended at them, as far as can be ascertained.

Operations.	Intrenching tools provided.	Intrenching Tools expended.	Duration in Days.	Authority and Remarks.
Capture of Olivenza, 1811	225	. .	3	Jones's Journal of Sieges.
2nd siege of Badajos, 1811	3,500	. .	13	
3rd siege of Badajos, 1812	3,000	1,500	20	
Siege of Ciudad Rodrigo, 1812	2,200	. .	10	
Siege of the Forts of Salamanca, 1812,	400	. .	10	
Siege of Burgos, 1812	600	2,000	32	A French depôt was found.
Siege of San Sebastian, 1813	4,000	. .	59	Jones's Journal.
Siege of Saragossa, 1808 and 1809 . .	20,000	. .	52	
Siege of Tortosa, 1810	10,000	. .	13	Rogniat Relation des Sièges.

Return of Intrenching Tools and Engineers' Stores, embarked for Service of the Army, under the command of Major General Sir Edward Packenham.

29th October, 1814.

Spades	1700	Saws, crosscut, setters	6
Spare helves for ditto	50	,, pit	6
Shovels, iron	400	Saw, pit, files dozens,	6
Ditto, with long handles	250	,, ditto setters	4
Pickaxes	50	Adzes, wheelers'	80
Ditto, miners'	50	Ballast baskets	1000
Spare helves for pickaxes, common	200	Sand-bags, bushel	60,000
,, ,, miners'	50	Iron crows, 5½-feet	35
Mattocks	360	,, 4½-ditto	35
Barrows, wheel	390	Spikes, 10-inch	1600
,, hand	140	Screw-drivers, large T	12
Hand, hatchets	928	,, common	10
,, bills	400	Chisels, firmer	7
Axes, felling	721	,, socket	10
,, broad	286	Screw jacks, large	5
Planes, long	6	,, small	17
,, trying	3	Drawing knives	26
,, jack	7	Gimlets, spike dozens,	5
,, smoothing	6	,, common ,,	10
Saws, hand	6	Hand hammers, claw	100
,, ditto files dozens,	3	Iron squares, figured	30
,, ditto setters	3	Stones, rag dozens,	10
,, crosscut	36	,, grind, with troughs	5
,, ditto files dozens,	18	Drag chains	13

Rope coils, white, 3-inch		7
,, 2½-do.		9
,, 2-do.		6
,, tarred, 3-inch		17
,, ,, 2-do.		17
Blocks, 10-inch, treble		2
,, double		15
Masons' levels, 5-feet		20
Penmauls		180
Iron assorted	Flat, 99 bars	cwt. 66
	Round, 86 do.	
	Square, 24 do.	
	Casement, 10 bundles	
	Nail rod, 18 do.	
Steel, sheer	cwt.	½
,, blister	,,	½
Forge carts with bellows		6
Anvils		6
Bick irons		6
Painted covers		6
Grease boxes		6
Spare bellows, forge cart		4
Chests of tools		6
Gouges		20
Augers (8 to a set)	sets,	20
Lanthorns, Muscovy		8
,, tin		38
,, dark		12
Oil, sweet	gallons,	5
,, linseed	,,	20
Carts, trench		50
Horse harness rope, near and off wheel	sets,	100
Whips		50
Leggins		50
Stoppers and lanyards	50,	100
Headstall halters with chain reins		100
Handscrew levers, 6 feet		10
Birch brooms		30
Coals	chaldrons,	38½
Chalk	cwt.	2
Chevaux de frize	barrels,	30
Spears for ditto	bundles,	30
Tarpaulins, large, for covering temporary magazine		9
Locks, stock, with staples		20
,, pad, with hasps and staples		16
Hinges, HL 12 inches	pairs,	16
,, hook and strap	,,	20
Sap forks		40
Fascine choakers		8
Sledge hammers, miners'		10
Spunyarn for tying fascines	fathoms,	2000
Platforms of oak for mortars: 16 × 16 feet	A, 13 planks	5
	B, 13 do.	
	C, 11 do.	
	D, 13 do.	
	E, 12 do.	
16 × 8 feet	S, 16 do.	3
	T, 16 do.	
	U, 16 do.	
Sleepers for do. 8 × 8 inches, 16 feet long		40
Spikes for platforms, 7 inches		1600
Fir timbers of different dimensions	about 700 feet running or cubical feet.	200
Fir boards, 1 inch	feet superficial,	1000

ARTIFICERS' TOOLS.

Sets of tools, carpenters'		3
,, masons'		8
,, collar-makers'		8
,, wheelers'		4
,, miners'		3
Masons' levels, 10-feet		8
,, 5-do.		8
,, plumb rules		8
,, facing rules, 6-feet		8
,, ,, 4-ditto		8

CAMP EQUIPAGE.

Tents, with poles, pins, and mallets, captains'		5
,, ,, subalterns'		7
,, round		6
For round tents, poles		6
,, pins		240
,, mallets		12
Blankets		100
Canteens, wood, with straps		100
Haversacks		100
Camp kettles		12

II.— *Notes on the Charges of Military Mines.* *By Lieutenant* DENISON, *Royal Engineers.*

VARIOUS rules have been laid down from time to time by the different authors who have written upon the subject of the charges of Military Mines, and as long as the radius of the required crater is equal to the line of least resistance, the results deduced from these rules coincide, or so nearly so as to render the difference unworthy of remark. They all agree that, in cases where the constant proportion between the diameter of the crater and the line of least resistance holds good, as the solids to be removed are in proportion to the cubes of lines similarly situated in each figure, or, which is the same thing, to the cubes of the lines of least resistance, the charges by which these solids are to be moved must be in the same proportion, and therefore, having the charge necessary to produce this effect in a given soil in one instance, we may calculate it in any other by the formula $x = \frac{c L^3}{l^3}$ when x is the charge required, c the charge of the experimental mine, L the line of least resistance of the required mine, l that of the experimental mine. Having then by experiment established a sort of scale of charges for any line of least resistance in a variety of soils, we have, by means of the above formula, the power of calculating the charges necessary to produce given effects, under the limitation at first expressed of the fixed ratio between the line of least resistance and the diameter of the crater.

The form of the crater has been variously assumed as a cone, a frustrum of a cone, or a paraboloid. The cone was assumed to have its apex in the center of the charge; this however was found to give too small a deblai. The frustrum of the cone had the radius of its smaller extremity equal to half that of the larger, and its solid content was equal to $\frac{11}{6}$ of the cube of the line of least resistance. The paraboloid, which was the figure assumed by La Valliere, had its focus in the centre of the charge, and its solid content differs in this case by $\frac{1}{29}$ in excess from that of the truncated cone. When the vertex of the paraboloid is cut off by a plane passing through the centre of the charge, the difference in excess becomes only $\frac{1}{276}$, a quantity quite inappreciable. We may therefore assume, that the frustrum of a cone, whose height is equal to the radius of its base, and to twice the radius of its smaller section, will be an approximation to the solid content of

the common or two-lined crater sufficiently close for all practical purposes. In different soils, experiment is the only guide to the quantity of powder necessary to raise a given mass; and this has shown, that in common earth $11\frac{1}{2}$ or 12 lbs. is sufficient to remove a cubic toise: from this follows at once the miner's rule, that the charge for a two-lined crater is equal to $\frac{1}{10}\,l^3$; and to the practical correctness of this rule all the authors who have written on the subject give their testimony.

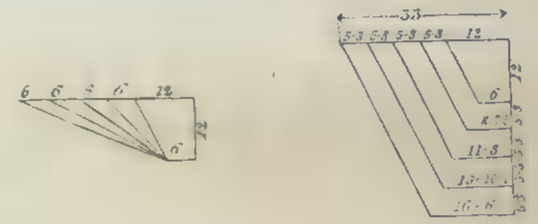
We owe to Belidor the discovery, that if two charges of powder be placed in chambers at the same distance under ground, one being sufficient to produce a common crater, and the other much larger than necessary for that purpose, the latter will produce a larger crater than the former. This seems to be a natural consequence; but many had denied the fact, under the idea that the powder, if used in excess, would only blow out for itself a sort of cylindrical hole; that in fact, the effect would, instead of increasing, diminish. Belidor tried a variety of experiments, and came to the conclusion, that as powder, when fired, would expand equally in every direction, the effect on the surrounding ground would be to form what he called a globe of compression, or a sphere whose centre was the centre of the charge, and whose radius was equal to the distance from this point to the edge of the crater. Having ascertained this distance in a common crater with the same line of least resistance as his globe of compression, and also in the latter, he considered the charges to be in the ratio of the cubes of these lines, forgetting that the solids were in no measure similar in figure. Other authors have followed Belidor in his general investigation, but have considered the charges as proportional to the squares of the radii of the crater. Others again, among whom is Colonel Pasley, have based their rules entirely upon experiment, without any reference to the figure of the crater, and have attempted to establish at once a fixed proportion to the cube of the line of least resistance, for the charge of each crater. The accompanying table shows at a glance the enormous discrepancies between the results deduced from the different rules.

Ratio of Charges, that for the Common or Two-lined Crater being Unity.

	One-lined Crater.	Four-lined Crater.	Six-lined Crater.
Mouzé	1	4	9
Belidor	1	4	11·2
Pasley	1	10	40

Colonel Pasley's rules, being based upon direct experiments, are more to be relied upon than the theoretical deductions of Mouzé and Belidor: but as others have arrived at different results, basing their calculations also upon experiments, though not of their own making, I shall proceed with the comparison.

General Marescot's rule says, multiply the squares of the radii of the craters by the radii of explosion, and the charges will be in proportion to the products; and in this case, the charge for a two-lined crater being unity, that for a four-lined crater will be 6·32, and for the six-lined crater 20·1. Messrs. Gumpertz and Lebrun take a different view of the subject, and say, that as a certain charge of powder (3660 lb.) with a line of least resistance of 12 feet, produced a six-lined crater, and this same charge, placed at the depth of 33 feet, will only produce a two-lined crater, thus this proportion will hold in all other mines, and their rule is as follows:—As 12 feet (the line of least resistance of the mine whose crater of 36 feet radius has been produced by charging it as a common mine of 33-feet line of least resistance) is to (a), the line of least resistance of a mine which is to produce a six-lined crater, so is 33, to x, the line of least resistance of a common mine, whose charge will produce a six-lined crater at line of least resistance (a).



And the lines of least resistance of other surcharged mines will vary in the following proportions deduced from the figure:

	Radius of Crater.	Lines of least Resistance of common Mine.
3-lined crater	18	17·3
4 „ „	24	22·6
5 „ „	30	27·9
6 „ „	36	33·0

The charges calculated by this rule are as follows, the charge for the two-lined crater being taken as the unit.

Two-lined Crater.	Four-lined Crater.	Six-lined Crater.
1	6·64	20 8

Captain Macaulay follows the same principle as Messrs. Gumpertz and Lebrun, but, using a different example, arrives at results differing in a slight degree from theirs. His charges for the different mines will be as follows:

Two-lined Crater.	Four-lined Crater.	Six-lined Crater.
1	6·33	19·7

M. d'Obenheim concludes, from various calculations, that the charges of mines with the same line of least resistance, are as the fourth powers of their radii of explosion; or more generally for all mines, that they are directly as the fourth powers of the radii of explosion, and inversely as the lines of least resistance: this formula gives the charges for the four and six-lined crater, with reference to that of the two-lined crater as unity, as below.

Two-lined Crater.	Four-lined Crater.	Six-lined Crater.
1	6·25	25

The following table gives at one view the proportions of the charges, as determined by different authors.

Common or Two-lined Crater.	Four-lined Crater.	Six-lined Crater.	Names of Authors.
1	4	11·2	Belidor
1	4	9	Mouzé
1	6·64	20·8	Gumpertz and Lebrun
1	6 33	19·7	Capt. Macaulay
1	6·25	25·0	d'Obenheim
1	10· 0	40·0	Colonel Pasley
1	6·32	20·1	Marescot
1	8	27·0	When the radius of the crater is taken as the line of least resistance, of a common mine.

The conclusion forced upon us by the discordant results in the above table is, that data are yet wanting for the determination of the charges of mines, the radii of whose craters exceed the line of least resistance. Any facts therefore which bear upon the subject will be most valuable, as we can only hope to arrive at a practical conclusion from the collation of numerous experiments made under every variety of soil and line of least resistance.

The following experiments were made at Tournay, by Messrs. Mesgrigny and la Motte, in 1689.

No. 1 was made in a soil consisting of strong sand mixed with clay, weighing about 124 lbs. per foot cube. The line of least resistance from the surface to

the floor of the chamber was 12 feet; another chamber was placed directly beneath the first, at a distance of 12 feet from the sill of one to that of the other; a gallery was also driven at a distance of 10 feet from the chamber, and on the same level with it. This mine was charged with 200 lbs. of powder; the diameter of the crater was 24 feet: the explosion destroyed the chamber below and eight feet of the gallery leading to it: it injured the gallery on the same level as the chamber, but did not altogether destroy it. The quantity of powder required to raise a cubic toise by this experiment appears to be 13 lbs. 10 oz.

No. 2 was made in the same soil as No. 1. The line of least resistance being 23 feet, a gallery was driven on the same level as the chamber, and 28 feet distant from it: it was charged with 400 lbs. of powder. The explosion destroyed the gallery, but took very little effect on the surface of the ground.

No. 3 was made in the same soil, the line of least resistance being again 23 feet: a gallery was driven at a distance of 22 feet from the line of least resistance and 10 feet above the charge. This gallery was filled with stone; the charge was 600 lbs.: the explosion destroyed the gallery, but produced little effect on the surface.

No. 4 was made in the same soil, the line of least resistance being 25 feet. The charge 1386 lbs.; the diameter of the crater made by the explosion was 50 feet, and the quantity of powder, per toise cube, 10½ lbs.*

No. 5 was made in the same soil, the line of least resistance (described as in the last case) being 12 feet. The charge 150 lbs.; the diameter of the crater 24 feet; and the quantity of powder, per toise cube, 10 lbs. 4 oz.

No. 6 was made in the same soil, but going deeper it was necessary to pierce a stratum of indurated sand, the weight of which was 126 lbs. per cube foot. The line of least resistance measured, as in the two last cases, was 35 feet: the charge 4000 lbs. The diameter of the crater 70 feet, and the quantity of powder, per toise cube, 11 lbs.

No. 7 was made in the same soil. Two chambers were placed, each having a line of least resistance of 12 feet: the distance between the chambers was 10 feet, and the charge of each 100 lbs. They were exploded simultaneously: the diameter of the crater in one direction was 30 feet, and the other 21, and the quantity of powder, per toise cube, 10¼ lbs.

* In this experiment the length of the line of least resistance is explained in a different manner than in the preceding. Here the expression is, "Le fourneau ayant 25 pieds de terre par dessus."

No. 8 was made in the same soil, with a line of least resistance of 12 feet: the charge was 300 lbs. The diameter of the crater 30 feet, and the quantity of powder, per toise cube, 5 lbs.

No. 9 was made below a mound of earth rising four feet above the surface of the ground. The chambers were made at the angles of a square, and the lines of least resistance were in all cases 20 feet, and the charges 450 lbs.; but the explosion produced hardly any effect.

No. 10 was made in a strong clay, of which a foot cube weighed 133 lbs. The line of least resistance was 15 feet, and the charge 300 lbs. The diameter of the crater was 30 feet, and the charge, per toise cube, 10½ lbs.

No. 11 was made in an old mass of masonry, the thickness of which at bottom was 10 feet, at top 8 feet, its length 20 feet, and height 42. A chamber was made at the centre of the mass, on a level with the ground, and charged with 80 lbs. of powder: the effect was very good, the bottom of the mass being blown out.

No. 12 has not sufficient detail to render it useful.

No. 13 was made at Mont d'Anzen near Valenciennes, in a loose sand, of which a foot cube weighted 132 lbs. The line of least resistance was double, the chamber having 15 feet of earth over it, and 15 feet between it and the scarped side of the mound. The charge was 300 lbs.; and the explosion produced a practicable breach 30 feet wide, most of the effect having taken place laterally.

No. 14 was made in the same mound. The line of least resistance vertically was 18 feet, and horizontally 35 feet: the charge 450 lbs. The diameter of the crater was 36 feet, and no effect was produced on the scarped face of the mound. The charge, per toise cube, was 9 lbs. 1 oz.

No. 15 was made in the same mound. The line of least resistance vertically was 30 feet, and laterally 46 feet. The charge 2050 lbs. The diameter of the crater was only 48 feet, which was attributed to the want of consistence in the soil.

No. 16 was made in the same mound. The line of least resistance being vertically 45 feet, and laterally 66 feet: the charge 6900 lbs. The diameter of the crater was only 72 feet.*

No. 17 was made at an old tower near Valenciennes: this tower was built on a mound of made earth; its foundations were 19 feet deep and 11 thick, made

* In the two last experiments the charges were too small to produce two-lined craters.

of good rubble masonry; it was square, each face being 40 feet long. Above the foundations, one angle was formed of two masses of masonry, 42 feet high, 10 feet thick at bottom, and 8 feet at top; one of these masses was 28 feet long, and the other 20 feet. The other portions of the tower above ground had been demolished previous to this experiment. The mound surrounding this tower was 20 feet high, 173 feet in diameter at bottom, and 146 feet at top. The powder was lodged in four chambers under the angles of the tower; under the part where the heavy fragments of the wall were left standing, a charge of 2000 lbs. was placed; there were two charges of 1300 and one of 1200 lbs.; the mines were exploded simultaneously; the effect was to lift the tower bodily out of the ground to the height of 10 feet, after which it crumbled to pieces.*

No. 18 was made in a strong clay, the cube foot of which weighed 133 lbs.; the line of least resistance was 15 feet; the charge 308 lbs.; the diameter of the crater 30 feet; and the charge, per toise cube, 10⅓ lbs.

No. 19 was made in the same clay; the line of least resistance was 29 feet; the charge 2300 lbs.; the diameter of the crater 58 feet; and the quantity of powder, per toise cube, 11⅛ lbs.

No. 20 was made in the same soil, but on sinking deeper, below the clay, a stratum of indurated sand was found, and the mean weight of a cubic foot of the whole was 136 lbs.; the line of least resistance was 41 feet, and the charge 6700 lbs.; the diameter of the crater 82 feet, and the charge, per toise cube, 11½ lbs.

No. 21 was made in a soil of which the first seven feet was a strong clay, weighing 140 lbs. per foot cube, and below that an indurated sand weighing 132 lbs. per foot cube; the line of least resistance laterally was 12 feet, and vertically 20 feet, the mine being placed above an old stone quarry; the charge was 150 lbs. and the explosion took effect in a lateral direction; not horizontally, for the earth on a level with the chamber was not affected.

No. 22 was made in the same spot, but the chamber was placed in the clay; the line of least resistance was 7 feet, the charge 35 lbs.; the diameter of the crater 14 feet, and the charge, per toise cube, 12 lbs.

No. 23 was made in the glacis of the citadel of Tournay; the soil was clay mixed with sand, weighing 150 lbs. per foot cube; the line of least resistance 17 feet; the charge 500 lbs. of powder; the diameter of the crater 39 feet; and the charge, per toise cube, 12 lbs.

* The inside of the tower was vaulted, but the vaults were filled with rubbish.

No. 24 was made in the same place; the line of least resistance being 21½ feet; the charge 900 lbs.; the diameter of the crater 43 feet; and the charge, per toise cube, 10⅔ lbs.

No. 25 was made in the same place; the line of least resistance was 34 feet; the charge 3600 lbs.; diameter of crater 68 feet; and charge, per toise cube, 10 lbs. 13 oz. This explosion destroyed the pier and one of the galleries of the counter-mines of the citadel, although it was built of good masonry, and was 56 feet distant from the chamber, on the same level.

No. 26 was made in the same place, in a soil mixed with rubbish, which had been made about 15 years, but had not much consistence; the line of least resistance was 20 feet; the charge 660 lbs.; the diameter of the crater 40 feet; and the charge, per toise cube, 9½ lbs.

III.— *Account of the Demolition of the Glacière Bastion at Quebec, in* 1828.

In order to proceed with the new works, according to the plan laid down for the formation of a Citadel at Quebec, it became necessary to remove a portion of the old French works, called the Glacière Bastion, to give place to a new counterguard, intended to cover the escarp of both faces of Dalhousie Bastion, from the high ground on the Plains of Abraham.

The 5th company of Royal Sappers and Miners having been out of England between four and five years, and the arduous duties of the corps in Canada affording them little or no time for instruction in their field duties, it was considered that the demolition of this work, by a system of mines, would not only afford most useful instruction to the company, but would probably be the most economical and effectual method of shaking down its escarp.

The commanding engineer having given his permission, and obtained the sanction of the commander of the forces, the company commenced driving the galleries Nos. 1, 2, and 3 by day-work, and continued them till they had formed junctions with each other: and, with the exceptions of meeting with rock or masonry, each squad generally averaged about eight feet a day. The nature of the soil was clayey, occasionally mixed with fragments of rock; made ground, but having acquired, from the length of time it had lain together, a considerable degree of compactness.

The galleries being completed, the company was told off in three brigades, consisting of one serjeant, three corporals, and nine privates, with orders to relieve each other every six hours; and the remainder of the company off duty were employed in making the coffers, hose, and casing-tubes; and occasionally relieved such men as felt oppressed by too long confinement under-ground.

On Monday, the 11th of February, the branches and chambers were commenced, at the points *x*, *y*, and *z*, leaving each squad nearly an equal portion of labour; and, as soon as the coffers were properly fixed and filled, and the train laid, each squad commenced a fresh branch, and the excavation was employed in tamping the one just completed. (*See Plate.*)

By this arrangement, the whole of the branches and chambers, measuring about 370 feet in length, were excavated, the powder placed in the chamber, the train laid, and the whole tamped up, and ready for explosion, on the Monday following. A coffer 13 inches cube, containing 70 lbs. of powder, was placed its own depth in each counterfort, at its junction with the scarp; and another of 12 inches cube, containing 50 lbs., was placed its own depth in the back of the scarp, equidistant from those in the adjacent counterforts.

The line of least resistance, opposite the 70 lbs., was nearly 9 feet, and opposite the 50 lbs., nearly 8 feet, and the average height of the scarp was from 21 to 25 feet.

It is not thought necessary to enter into the detail of the dimensions of the galleries, branches, &c. as the system pursued was strictly conformable to the instructions received from Chatham.

On Tuesday, the 19th of February, the Earl of Dalhousie, Governor General, and Commander of the Forces in his Majesty's North American Provinces, accompanied by his staff, and a great number of others, both civil and military, attended to witness the explosion.

The galleries being in several parts very wet, and fearing from the length of time it required to prepare the mines, that the powder in the hose might get damp, it was determined to fire the mines at the three points, 1, 2, and 3, and thereby produce a more simultaneous explosion: but the sapper stationed at No. 3, having taken the signal from the bugle where his Lordship and the spectators were stationed, instead of waiting for the repeating bugle on the spot, the whole of the mines, 20 in number, were exploded from that point.

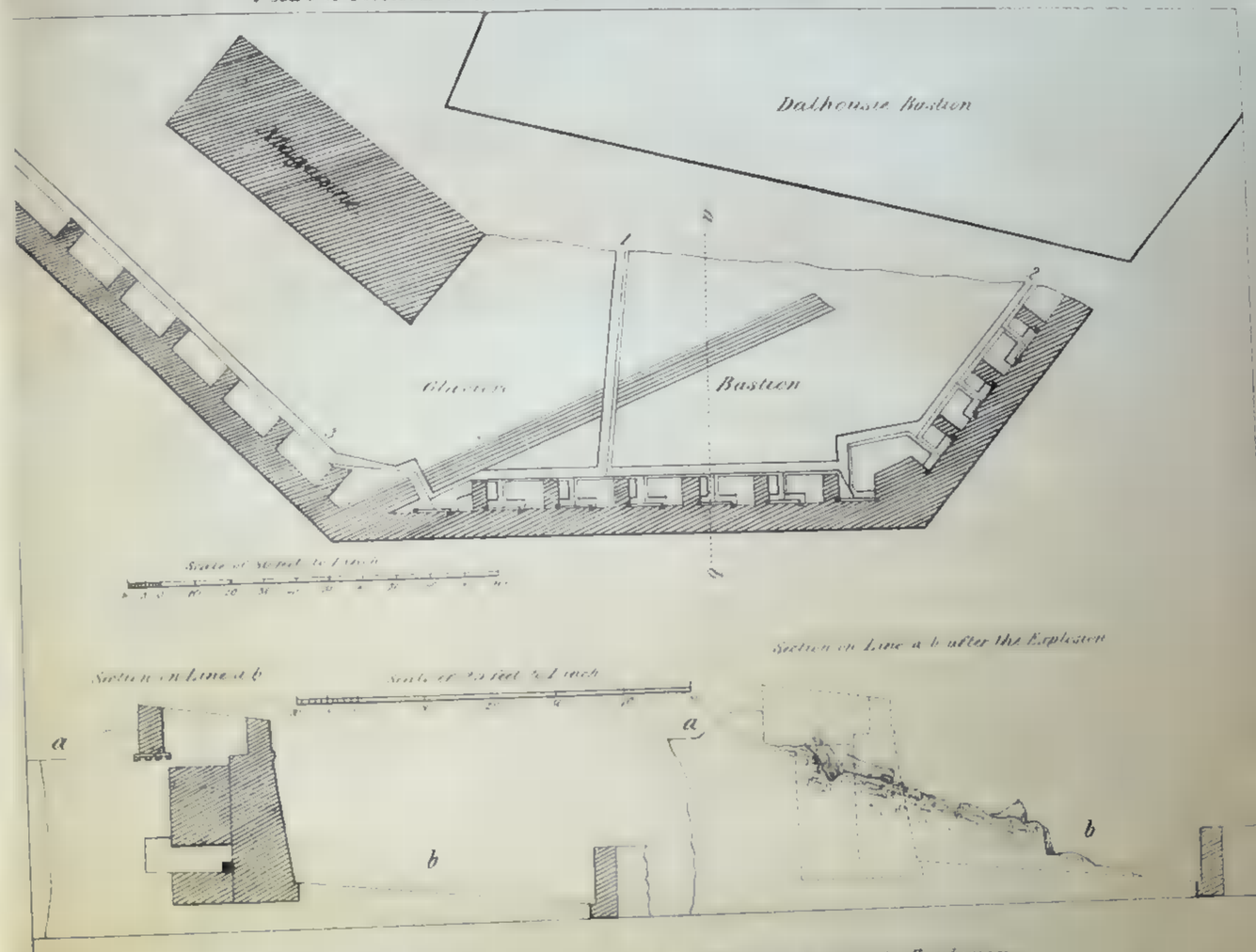
The effect produced far surpassed the most sanguine expectations of the officers employed upon this service.

The explosion not only crumbled the escarp to pieces, without projecting a stone 50 feet from its original position, but brought down the whole of the parapet, together with its interior revetement; forming throughout the whole line a most practicable breach.

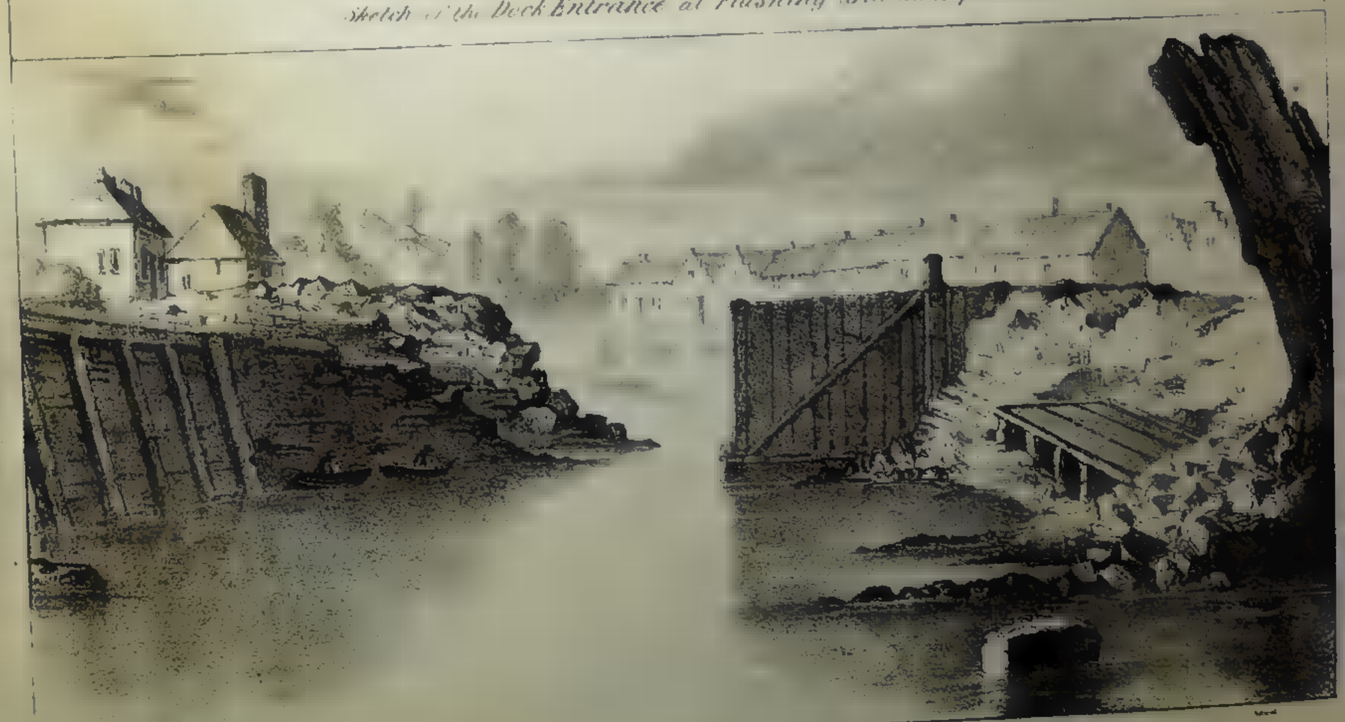
The only parts which descended in masses were the exterior revetement of the parapet, and the earth between that and the interior revetement, showing the enormous power of the intense cold in Canada, which strikes nearly four feet into the ground.

The escarp was of rubble masonry, and in an excellent state of preservation.

Plan & Sections of the Glacieve Bastion at Quebec.



Sketch of the Dock Entrance at Flushing after the Explosion.



Remarks deduced from the foregoing Practice.

1st. As the mines were exploded from one point, instead of three as intended, and as the interval of time between the first and last explosion, in a distance of at least 220 feet, did certainly not exceed three seconds, it is presumed that a simultaneous explosion of mines (requiring great length of hose, much time to adjust, and great additional labour), can seldom or never be required, and if resorted to, that the effect would not be materially increased.

2ndly. From the immense masses in which the earthen parapet descended without being shaken, it is almost evident that, in a cold climate, during the winter season, rock may be excavated with greater facility than earth, when both are equally exposed to the effects of frost.

3rdly. That the distance to which a gallery may be driven without the aid of bellows, depends entirely upon the state and temperature of the atmosphere. In the present instance, No. 1 was driven at least 140 feet, and the lights burnt tolerably well, though eight men were frequently employed in it.

CAPTAIN MELHUISH,
Royal Engineers.

IV.—*Memoranda on the Demolition of the South Face of Fort Schulemburg, Corfù. By Major* MARSHALL, *Royal Engineers.*

THE mines in the South face of the redoubt Schulemburg, in the Island of Vido, were begun on the afternoon of the 2nd of May, by driving galleries from the face to the back of the escarp, with returns of 8 feet right and left to the chambers, which were cut their full size in the back of the escarp, and loaded with 205 lbs. of powder in each.

General Dimensions

	Ft.	In.
Thickness of escarp at top	3	6
Do. at base	6	0
Height of escarp	20	0
Distance of galleries from centre to centre	28	0
Do. chambers	14	0

The galleries from front to rear of the escarp were about 3 feet wide, and 4 feet high; and the returns at their ends were $2\frac{1}{2}$ feet wide, and 3 feet high; the chambers were cubes of 2 feet, the boxes being of the same figure, 19 inches in the clear; the galleries and branches being mostly cut through solid rock or tough masonry, it was difficult to keep to exact dimensions, but they were adhered to as much as possible.

One miner and two labourers were employed in each gallery and its return (when two returns were opened, these parties were doubled): the working hours ten each day. In some of the galleries, the masonry was only 18 inches or 2 feet thick, and then hard rock; in others, after piercing the wall its whole thickness, the earth at the back was such as to require frames with top and side sheeting, and in others, a mixture of clay and thin layers of rock: thus the branches meeting a variety of soil. The miners were attached at 12 points at first, but one party was removed, it being determined to blow up two small casemates, near the centre of the face, by placing a chamber on each side of the pier dividing them, loaded with 375 lbs. of powder: the line of least resistance being about 14 feet, whilst those in the returns had about five feet, but in solid rock or masonry. On the 29th of May, the loading and tamping was

commenced; and on the 10th of June the whole was exploded. The lengths of hose to all the chambers were equalised as nearly as possible, with only one focus of ignition. The explosion of the several charges was so simultaneous as not to show the slightest division in their effects, which, considering the variation of the distances of the centres of the galleries, through the escarp, from the focus of ignition, and the dampness which the hoses had contracted from sudden and unexpected rains, might have been expected. To remedy the latter, we had to cut off and replace from 3 to 4 feet of most of the hose ends: the perpendiculars for equalising the hoses were 6 feet, except those joining the last parallel, which were 12 feet; less might suffice where there are only two parallels of hose: but, as in this case we had four parallels, we were afraid of placing them nearer than 6 feet, lest, by the explosion, they should communicate across the arrangement. The casing-tubes were merely bedded in grooves cut in the earth, the lids lightly pegged on, and, at every 6 or 8 feet, two small pickets were made to cross each other over the tube, to keep it from being thrown off, and thereby drawing the hose not yet exploded out of its place. From what we experienced, it would appear advisable (under even the most favourable circumstances) to stop the jointing of the powder-boxes and casing-tubes with a composition, or putty, made of sweet oil and chalk. The branches being small, the powder-boxes were filled at the magazine, a hole being left to receive the return of the casing-tube (but stopped with clay and hay till actually placed in chamber): the casing-tube, with its hose properly secured, was thrust 4 to 6 inches into the powder-box. The casing-tubes, when fitted and adjusted in their lengths, were built in, in a drain of dry masonry, to prevent their being disturbed in the tamping.

The tamping consisted of alternate layers of stone and gravel: the latter filled the joints, and formed the beds for the courses of stone; and the stone itself being carefully packed and built in, the whole formed a dense and compact mass. Across the mouth of the chambers strong palisades were laid horizontally, one above another: the same was done across the junction of the gallery with its returns. The powder-boxes were of 2-inch fir plank; but this was stronger than requisite: 1 inch in small, and $1\frac{1}{2}$ inch in larger ones being sufficient. The sides were dovetailed, but treenailed would have done. Half-inch fir plank is sufficient for the casing-tubes, made of four slips pegged together: no iron should be used in any of these. The working parties were distributed as follows:

One N. C. O. and four sappers to fill the boxes in the magazines and bring them to the mines.

Two N. C. O. and eight sappers divided into two equal parties, for placing the boxes in the chambers, and adjusting and laying the hose-tubes ready for tamping—one good carpenter amongst them.

Three sappers preparing hoses.

Five do. tamping parties.

The operation occupied five weeks' working time; but much delay took place from the small number of sappers at first employed, and the men not being quartered on the Island.

The effect of the explosion was most complete, the whole escarp, with the 12-feet parapet which crowned it, being thrown down *en glacis*, and forming a practicable road into the fort at more than one point; but particularly in front of the casemates, where a column of subdivisions might have stormed.

Corfù, June 12th, 1826.

V.—*A short Account of the Demolition of the Piers of the Entrance Chamber of the large Basin at Flushing, in* 1809. *By Colonel* FANSHAWE, *Royal Engineers.*

Such erroneous accounts having been offered to the public respecting those leading data which rendered the destruction of the piers of the flood-gates of the great basin at Flushing, in 1809, an interesting mining operation, it may be useful to any officer that feels disposed to compare the practical result on that occasion, with the calculations of theory, to have before him the following details, which have been taken from notes kept by me at the time of execution.

The evacuation of the island of Walcheren having become necessary, the British Government determined on, "the demolition of the sea-defences and basin of Flushing," and a body of nearly 400 civil artificers and "navigators" was sent from England, and placed under the officers of Royal Engineers to whom the work of demolition was confided.

The destruction of the piers of the flood-gates at the entrance of the basin, appeared to the officers the first object of consideration, and this was to be effected by mines, the disposition and charges of which should be so arranged, that the effectual destruction of the piers would not hazard that of the town by which the basin was surrounded.

The length of each pier was 128 feet; the thickness varied from about 27 to nearly 33 feet; and the height above the floor of the entrance-chamber was 26 feet; the whole of solid brick-work, except a small arched channel, or culvert, which ran longitudinally through the upper part of each pier.

The object being to render these piers unserviceable with the least possible injury to the town of Flushing, it was proposed so to place the charges that the foot of each wall should be blown into the entrance, or lock-chamber, and that the upper part of the wall, instead of being thrown upwards by the immediate effect after explosion, should fall as its consequence; or be so rent as to be incapable of partial repair.

The position fixed upon for the charges, was 2 feet above the floor of the lock-chamber, and with a line of least resistance towards the face of each pier, of 9 feet.

The explosion was to take place at low tide, when there would be 7-feet depth of water in the entrance-chamber.

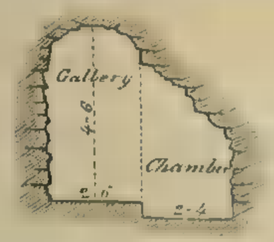
Four mines were determined for each pier, to be equally distributed and fired together; the charge of each to be three barrels of gunpowder, or about 270 lbs.

A shaft 7 feet square was sunk for each mine, in the ground immediately at the back of the piers; and upon reaching the required depth in each, a gallery, 4 feet 6 inches high, and 2 feet 6 inches wide, was driven through the brick-work to the position for the charge.

The miners were divided into gangs of six to each mine, and each gang was subdivided into three reliefs; so that two men were in the gallery at a time, one working with a pole-pick and wedge, or a hammer and chisel, whilst the other was clearing out the rubbish from the gallery, and filling the bucket, which was drawn up the shaft by two labourers.

The general average of work accomplished by the miners, was about 1¾ inch length of gallery per hour; some did more, others much less.

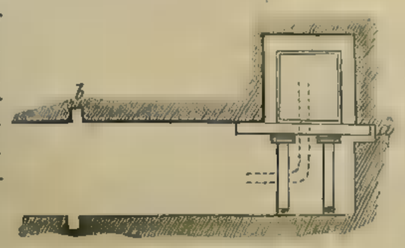
Having reached the length intended for each gallery, a return was made for the chamber, of which the following is a section.



The boxes to contain the charges were, in the clear, $19\frac{1}{4} \times 19\frac{1}{4} \times 22\frac{1}{4}$ inches, made of $1\frac{1}{2}$-inch deal; the bottom covered with tarpaulin, and the cover made to fit exactly, with ledges.

The auget was fixed to, or rather housed into, the centre of the side of the box towards the gallery; it was made $1\frac{1}{2}$-inch square in the clear, of $1\frac{1}{4}$-inch deal; the cover of it (after the saucisson was laid) was fastened with wooden pegs.

The saucisson was the leader of a fireship, about 1 inch diameter, filled with gunpowder, and afterwards passed through a painted canvass hose; the whole of which was laid in the auget.



Plan of the gallery and chamber showing the timber stoppages.

The mines being charged, the upper part of each chamber was filled in with bricks; then (a chase (*a*) being cut, as shown in this diagram,) planks were laid edgewise, so as to close the whole entrance: two stout planks were then placed vertically; and these were secured by four pieces of stout oak scantling, placed horizontally from the opposite side of the gallery, and wedged very tight. The whole space opposite the entrance of the chamber was stopped with bricks and filled sand-bags; then another partition of timber across the gallery, at the chase (*b*). The remainder of the gallery was built up with sand-bags, and at the entrance of the gallery another partition of timber was placed, and the whole of the lower part of the shaft, to the height of the gallery, was made as solid as possible with a bed of timber.

Throughout the gallery, and up the shaft, the auget had bricks built around it, to secure it from damp. The shaft was filled with sand-bags, bricks, and rubbish, to the very top.

A slight bridge was thrown across the entrance-chamber from pier to pier, and the mines were connected together by the saucisson, and fired by a portfire, equidistant from the centre of each charge, allowing 4 inches for every right-angle.

The mines were exploded at low water, and the flood-gates were opened. The effect of each charge (excepting two on the eastern side, where the powder had become damp, and the explosion consequently only rent the pier) was to blow out the bottom of the wall, and to destroy the adjoining part of the floor, which was of oak. The bottom of the piers being thus removed, the upper part almost immediately fell.

So completely was the desire that the town should not suffer fulfilled, that not even a square of glass was broken in the lock-house, situated about 30 feet in rear of the western pier, whilst the effectual destruction of the piers themselves assumed the appearance shewn in the annexed sketch.

EDWARD FANSHAWE,
Colonel, Royal Engineers.

VI.—*Extract of a Letter from Colour-Sergeant* HARRIS, *Royal Sappers and Miners, to Colonel* PASLEY, *Royal Engineers, giving an Account of the Mode in which a stranded Ship was blown to pieces.**

THE Arethusa was a ship of 350 tons, and went on shore in the hurricane of the 10th of August, 1831, close to the commanding Royal Engineer's Quarters at Barbadoes. I had orders from Major, (now Colonel) Reid, to try to blow her to pieces, which was done in the following manner. Two old oil tin cans, which held 30 lbs. each, were filled with powder; $\frac{1}{2}$-inch hose was then made with calico, filled and put through $1\frac{1}{4}$-inch lead pipe, which was then soldered to the tin cans. The ship lay on her larboard side with the keel about 2 feet out of the sand, and at low water, (which was about 3 feet deep on the outside of the ship, the side nearest the sea), we put one of the cans under her keel, about 10 feet from the stern, and brought the end of the pipe through the side of her, as it was the best place for firing. When it was high water, it was about 6 or 7 feet deep, and we then fired the charge, and made a hole in her about 10 feet long, and upon an average 4 feet wide, through her keel, planks, timbers, and lining, and carried a piece weighing nearly 100 lbs. to a great distance. The next charge was put under the keel the same way, about half way from the hole just made to the bow, and that load had also a good effect, but it did not carry away so great a piece as the first. The next was loaded in the same manner, but with only 24 lbs. of powder, that was put under her keel as before, but near the bow: this load did not carry off a great deal, but shook her much. We then got the lining off the bow; there were 5 knees or timbers still remaining, which held the ship together; we put a sand-bag on the lower one of the five, containing 24 lbs. of powder: the explosion of this broke the beam it rested on and the two above it: we put nothing against it, only a bit of wood, to keep it in its place before it was fired. The next charge contained the same quantity, and was put on the

* To procure the greatest resistance to the powder on the side next the sea, the charges were never fired until high water.

lowest one of the two that remained. When that was fired, the bow dropt in pieces: the stern was done in the same manner as the bow, and every load that was fired had the desired effect: one or two missed, in consequence of the water getting in the cans.

(Signed) JOSEPH HARRIS,
Late Colour-Sergeant, Royal Sappers and Miners.

Colonel PASLEY, C. B.
Royal Engineers.

VII.—*Notes on the Formation of Breaches by Artillery.*

The questions addressed by Marshal Soult to the different artillery schools in France, contain a summary of the points to which the attention of officers should be constantly drawn; and the published details of the experiments carried on at Metz, afford very valuable information upon those points which were investigated by the committee. I have, in the abstract I have attempted to give, confined myself altogether to the first experiment, for the purpose of establishing a comparison between the effect of the point-blank fire of artillery at short distances, with a full charge, and that of a plunging or pitching fire, (as shown in the experiment carried on at Woolwich, in the year 1822, against a portion of a detached escarp, constructed according to Carnot's system). I annex also, for the purpose of comparison, Note 34, from Colonel Jones's account of the 'Sieges in Spain.' In conducting these sieges, from the absence of a proper Engineer establishment, it was found impossible to carry the approaches up to the covered way, and establish batteries on its crest: it was necessary, therefore, to take advantage of commanding points at long distances, from whence the escarps could be seen to the foot, and there to erect heavy batteries for the purpose of opening a narrow and perilous road, through which the valour of the troops would enable them to force an entrance. Had the works of Badajoz, Ciudad Rodrigo, and St. Sebastian been properly covered from distant fire, all our efforts against them would have been perfectly futile. As it was, however, the sieges in the Peninsula present several remarkable instances of the efficiency of a well-sustained distant fire against the best masonry scarps.

W. D.

Abstract of the Experiments at Metz.

In the year 1833, Marshal Soult, who was then Minister of War, forwarded a circular letter to the different schools for the artillery throughout France, calling their attention to the various points upon which it was desirable that more precise

and definite information should be obtained. The following is the list of subjects referred to:—

1. To determine the relations which exist between the initial velocities of projectiles, and the charges of powder of equal weight, but of different strength, this strength being expressed by the ranges of the eprouvette, or by any other equivalent mode.

2. Between the initial velocity, the charge of powder, (the force of the powder being supposed constant) the weight of the projectiles, the calibre of the gun, the length of the bore, and the windage.

3. Between the range, the initial velocity, the weight of the projectile, and the angle of projection.

4. To ascertain the length of bore which gives the greatest range; the maximum charge; the effect of alteration in the length of the cartridge, in the shape and capacity of the chamber, and in the position of the vent.

5. To establish the law of the resistance of the atmosphere, and to explain the principal causes of the irregularities which affect the direction of the shot.

6. To explain the theory of ricochet firing; the relation between the initial velocity, the angle of elevation, the lengths of the first and second bounds of the shot, and the total range.

7. To make the necessary experiments to ascertain the penetrations of shot in earth, masonry, wood, metals, and liquids: the thickness necessary under different circumstances, and with various materials, to withstand the effect of shells: the effect of the explosion of shells from mortars and howitzers; the cavity created in earth by this explosion, either with the ordinary bursting charge, or with the cavity of the shell completely filled with powder.

8. To give a theory of the penetration of projectiles.

Marshal Soult then directs, that at each school a commission, composed of officers and professors, shall be formed, which shall report to him the particular objects in the above list with which they purpose to occupy themselves, the experiments which they conceive necessary to determine these objects, the amount of material necessary for the purpose, and the probable expense.

Of these questions, the three last are of the greatest interest to the officer of Engineers. Any facts which tend to throw light upon the theory or practice of ricochet firing, will guide him in his attempts to modify, or to neutralize altogether, the destructive effect of this system, when used in the attack of fortresses; while the resistance of different substances to the action of shot and

shells, forms a necessary element in the determination of the thickness of parapets and buildings intended to protect troops against the action of projectiles generally.

The report, therefore, of the commission appointed at the school at Metz, which devoted its researches principally to these points, is of great interest to officers of Engineers; and I have attempted, in the following pages, to give a brief abstract of the details of the first experiment, and of the conclusions derived from it, combining them, at the same time, with the information I have been able to procure from other sources upon the same subject.

The first experiment made by the committee was for the purpose, partly, of ascertaining the penetration of shot and shells of different calibres in masonry and earth; and partly of determining the best mode of directing artillery for the purpose of forming a breach, and the time required to render such breach practicable. With this object two batteries, one of four 24-pounders (French), and the other of four 16-pounders, were constructed opposite a portion of the left branch of the horn-work of the citadel of Metz, which work was constructed by Vauban, between 1676 and 1680: each battery was to form a breach about 20 metres in length, and a third breach was to be formed by the mine.

The revetement, which it was thus proposed to breach, was formed of rubble masonry, the facing of calcareous oolite from the quarries of Jaumont, and the interior of a species of blue limestone yielding an hydraulic lime. The mortar was composed of sand and hydraulic lime; the height of the escarp varied from 19 to 21 feet, measured from below the cordon to the bottom of the ditch; the thickness at the top was 4 feet 8 inches, and at bottom 8 feet 6 inches, with an exterior slope of $\frac{1}{5}$: it was strengthened in the rear, for its whole height, by counter-forts, 7 feet in length, 5 feet 4 inches wide at the root, and 4 feet at the tail, and 16 feet distant from centre to centre.

With regard to the quality of the masonry, the following facts will enable some idea to be formed. In forming a gallery by blasting, the miners were employed for twenty-one hours in excavating a cubic yard. Another gallery, excavated by the pick and chisel, required fifteen hours labour per cubic yard; while in an open coupure, country masons, working by the task, demolished a cubic yard in seven hours thirty-six minutes.

The 16-pdr. battery was placed in the re-entering place of arms, at the distance of 33 yards from the scarp, and the breach was commenced at the distance of 7 feet from the bottom of the ditch; the 24-pdr. battery was constructed on the

crest of the glacis, at a distance of 35 yards from the escarp, and the breach was commenced about 8 feet from the bottom of the ditch. The guns were placed about 16 feet apart; and as each of them had to form a horizontal section through the revetement of the same length, they were all at first directed to the left extremity of their allotted field of action, and after that every successive shot struck the revetement at about 1 yard to the right of its predecessor: 5 shots from each gun having thus marked out the breach, a steady fire was kept up at 5-minute intervals, with a charge of powder equal to half the weight of the ball, care being taken always to fire at the most projecting part of the masonry; and the result was, that the revetement was entirely cut through at the distance of 7 feet from the bottom of the ditch, by 212 rounds of the 16-pounders, or 53 rounds per gun. It was then decided to form five vertical sections, at intervals of five yards apart, so as to cut the revetement into four equal parts; and as there were only four guns employed, the two sections to the right and left were commenced first, leaving the centre section for the last. The fire was directed from below upwards, taking care to cut through the lower part completely, before beginning upon the upper, for fear of choking the lower part with rubbish from above, which would afterwards impede the effect of the shot. After ten rounds the revetment to the left of the breach fell, *en masse*, into the ditch, carrying with it the untouched mass, eleven yards in length, of the centre; and seven rounds more, from one gun, was sufficient to bring down the rest of the masonry, and form a breach twenty-five yards wide. The time occupied in forming this breach was five hours thirty-seven minutes; and as the mass of masonry amounted to two hundred and fourteen cubic yards, it follows that a cube yard of masonry was destroyed in little more than one minute and a half.

The breach thus formed was still very steep towards the top, where it was supported by the counter-forts, and it required twenty-six more rounds to complete their destruction, and to render the breach practicable. The breach was formed by the 24-pounders, in a similar manner to that described above, only the first shots were fired at a distance of 4 feet from each other, and the horizontal section was thus made after thirty-four rounds per gun. Four vertical sections only were made, dividing the breach in three parts, one eleven yards in length to the right, and two others of five yards and a half to the left, and after nine rounds per gun, the revetement fell into the ditch, bringing with it a large portion of the earth of the parapet; three rounds more, however, from the two guns to right and left were necessary to bring down a portion of

masonry which still adhered to the standing portion of the revetement. The breach thus formed was twenty-four yards wide, and the time occupied in forming it four hours three minutes. The mass of masonry destroyed was two hundred and five cubic yards, which corresponds to the destruction of a cubic yard in about one minute and a quarter. In comparing the results of the two operations, we find that the times are about in the inverse ratio of the calibres, and the expenditure of powder and shot is about equal in both cases.

The counter-forts still supported the earth in a steep slope at the top of the breach, and it required thirty-eight rounds to render it practicable, and even then the parapet had a mean thickness of 11 feet 6 inches in both breaches after the destruction of the masonry. Eight-inch howitzers were employed with different charges, for the purpose of cutting away the parapets. With a charge of 2lb. the shells did not penetrate far enough into the ground to be of any service, and their explosion taking effect towards the exterior, was more dangerous to the besieger than the besieged: with charges of 2lb. 10oz. and 4lb. the penetration was about one yard, and 5lbs. of bursting powder, produced a great effect in bringing down the earth of the parapet: with a charge of 5lb. it often happened that the fuze was broken off close to the shell, before the composition had time to burn below the point of rupture, so that in these cases the shell did not explode.

Some 5-inch shells were fired from the 24-pounders, but their effect was very trifling; they could not be fired with a larger charge than 1¼lb. without the risk of breaking to pieces against the sand and gravel of the parapet, and with this charge their penetration was so small as not to produce any sensible effect.

The general rules on the subject of forming breaches by cannon, as deduced from a comparison of the above experiments, with those adduced by Vauban, Gassendi, and others, are as follows:

1st. With regard to the position of the battery. This is generally determined by the nature and position of the work to be breached; but as a general rule, a sufficient distance should be left between the breach and the salient of the work, to allow space for the lodgment, and to render it unnecessary to cut away the salient angle itself. It is advisable therefore to advance towards the gorge of the ravelin, or the shoulder of the bastion, so as to fulfil this object, without however interfering with the descent into the ditch, or exposing the battery to a close and plunging fire.

To determine whether the battery shall be placed in the covered way, or in the lodgment on the crest of the glacis, a section must be made, showing as

correctly as possible the height of the escarp, breadth of ditch, &c.; and then deciding at what height from the bottom of the ditch it will be necessary to cut through the escarp, in order to ensure a practicable breach. By the experiments before detailed, it is plain that the breach would have been perfectly practicable had the horizontal section been made at half the height of the escarp, but it was thought better to begin at about one-third from the bottom of the ditch: the height of the escarp was here only 20 feet, and as this height cannot be said to secure a place from escalade, and as the breach was perfectly practicable, though commenced at 6 feet from the bottom of the escarp, it may be laid down as a rule, that the horizontal section should never be commenced nearer than 6 feet to the bottom of the ditch. This is contrary to Vauban's opinion, who says that it should be made at 2, 3, 4, 5, or at most 6 feet; and to Bousmard, who says it should be made as low as possible.

Having fixed the point at which it will be proper to make the horizontal section of the escarp, it will be easy to decide whether the battery should be placed in the lodgment, or in the covered way: it is hardly necessary to add, that wherever it is possible, it should be placed in the former. The mode of making the horizontal section before detailed, seems preferable to that prescribed by Vauban, who recommends that the fire of all the guns should be concentrated upon particular points, and continued until the masonry be completely cut through. As to the fire by salvos recommended by Bousmard, it was found in the first place to be impracticable, as whatever attention was paid both to priming the guns and firing by word of command, some delay always took place between the fire of different guns, even when they were all collected in battery close to each other; much more therefore must this be the case on service where, generally speaking, the guns are placed in pairs, each pair being separated by a traverse. Should it even be found practicable to fire in salvos, the vibration in masonry extends to so small a distance from the point struck, that the effect produced by the shock of shot striking the wall simultaneously, at distances of 3 or 4 yards from each other, would not differ from that produced by consecutive blows.*

2nd. With regard to the vertical sections, it appears from the experiment, that

* A breach was formed at Ehrenbreitstein by a battery of four 24-pounders, firing with a charge of 10 lbs. of powder, at a distance of 40 yards. The scarp was formed of a badly cemented wall of greywacke; the guns were fired in salvos at every second round; and at the 43rd round the breach was considered practicable.

an interval of 30 feet may be left between them; Bousmard recommends but two, one at each extremity of the breach. As a general rule, however, it appears advisable to form as many vertical sections as there are guns in battery; taking care that the two extremes, which determine the length of the breach, should be made if any thing quicker than the intermediate sections.

The authors who have written on the subject of the attack of fortresses, differ materially in their statements of the time required for the formation of a breach. Gassendi, in the Aide Memoire, allows four or five days, and three days more to render it practicable after the fall of the revetement; Bousmard gives 36 hours. The experiments above detailed seem to show that this is far beyond what is necessary, as the 16-pounders formed a breach in 5 hours 37 minutes, and the 24-pounders in 4 hours 3 minutes, after which about 50 minutes more were required to destroy the counterforts, and forty 8-inch shells after that rendered the breach completely practicable. If we allow then two hours as the time necessary for removing the guns, and substituting howitzers in their place, the assault may be given within four hours after the fall of the revetement; so that the whole operation would require with the 16-pounders, 9½ hours, and with the 24-pounders, 8 hours.

The third breach which was formed by the mine, was about the same size as those formed by the batteries: it required 306 hours labour, and was charged with 1544 lbs. of powder in five chambers: viz. two at the tail of the counterforts to the right and left of the breach, with a charge of 464 lbs. in each; two in the intermediate counter-forts, charged with 200 lbs. each; and one in the earth in rear of the breach with a charge of 216 lbs. The explosion of these mines threw the masonry in large blocks into the ditch, but these were not covered with earth, and the breach, although practicable, was difficult of access. There were five blocks of masonry of more than one cubic yard, two of more than two cubic yards, three of more than three cubic yards, and two lying contiguous to each other, one of eight, and the other of six and a half cubic yards.

W. D.

Report of Experiments carried on at Woolwich, in the Year 1822, against Carnot's detached Revetement.

In the summer of 1822, the Duke of Wellington being Master-General of the Ordnance, it was determined to make experiments on the possibility of breaching walls protected by earthen counter-guards, as proposed by Carnot, in his system of defence, by firing over the crests of such counter-guards.

It was first desirable to ascertain the smallest elevation which shot could be fired, if it were practicable to throw shot at all, which clearing the counter-guard, should fall sufficiently in their flight between it and the wall, to strike the latter low enough to open a practicable breach, and what charge and elevation were most suitable for this purpose; and next it was to be determined, whether shot so thrown had sufficient momentum to ruin masonry.

Experiments were accordingly made with the first object, in twenty-eight days, between August 2nd and September 24th, 1822, by firing over a bank of earth, 66 feet long, and in section similar to the upper part of Carnot's counter-guard, having its crest 12 feet above the level of the experimenting batteries. The distances from the top at which the different shot would have struck the wall, were known by the height at which they struck a bank of earth thrown up at the proper distance (60 feet), in rear of the counter-guard; and, for those which struck the ground between the two mounds, by measuring the distance from the foot of that in rear, and all which were stated to strike lower than 12 feet, were therefore thus obtained.

The two first days' practice were considered as preliminary: from the results of the others it was decided, that with elevations of 10° and 11°, it was not possible to strike the wall lower than 16 feet from the top; that only 2-7ths of the shot and shells so fired would take effect upon the wall at all; and of those that did, only about 1-28th at more than 12 feet from its top, or 1-97th of the whole numbers fired. This opinion was formed after 487 rounds from different descriptions of heavy ordnance had been fired, at ranges of 400 and 500 yards, with elevations not exceeding 11½°.

Four hundred and eighty rounds, at similar ranges, were fired at elevations of 15°, and it appeared that between 2-7ths and 3-8ths would have taken effect, of which 3-7ths, or 1-6th of the whole number of rounds, would have struck the wall lower than 12 feet from its top. The details are given in the following table:—

Results of Experimental Practice made at Woolwich in August and September 1822, to ascertain whether it would be practicable to fire Shot over Carnot's Counter-guard, and strike the Wall in rear low enough to open a Breach.

Days of Practice.	Date.	Nature of Ordnance.	Range.	Charge.	Elevation.	No. of Rounds.	Shot or Shells struck the Wall from Top, at: 1 to 2 feet.	2 to 4	4 to 6	6 to 8	8 to 10	10 to 12	12 to 14	14 to 16	16 to 18	18 to 20	20 to 22	1 to 12	12 to 22	Total.	Proportion: Of Rounds which struck the wall.	Of those striking the Walls that struck below 12 Feet.	Of the whole Number of Rounds fired that struck below 12 Feet.
3rd	Aug. 7	24-pounder iron 9 ft.	400 yards.	lb. oz. 0 12 10		37	2	5	..	1	..	..	..	..	..	..	..	8	..	8	more 1-5th		
5th	9	do. do.		1 0 9¾		30	3	2	1	..	4	1	..	..	..	..	..	11	..	11	more 1-3rd		
9th	16	68 carronade wt. shot		1 0 9¾		30	4	2	1	2	1	2	..	..	..	..	..	12	..	12	2-5ths		
10th	19	do. do.		1 0 9¾		20	..	2	4	..	2	2	..	..	..	..	..	10	..	10	1-half		
				1 4 7½		30	..	2	..	6	..	2	..	..	..	..	..	10	..	10	1-3rd		
21st	Sept. 4	do. do.		0 14 11½		20	1	..	..	..	..	3	..	1	..	..	..	4	1	5	1-4th		
26th	Aug. 27	8-inch iron howitzer		1 0 9¾		40	..	2	4	2	..	1	..	..	..	..	..	9	..	9	near 1-4th		
		8-inch iron howitzer		1 6 10		40	3	2	1	1	2	1	..	..	..	..	..	10	..	10	1-4th		
		Total—not exceeding 11½° elevation at 400 yds. range	400	..	..	247	13	17	11	12	9	12	..	1	..	..	..	74	1	75	more 3-10ths	1-75th	
4th	Aug. 8	24-pounder iron 9 ft.	500 yards.	0 9 10¾		40	2	..	1	2	..	1	1	..	..	..	..	6	1	7	more 1-4th		
6th	Aug. 12	8-inch iron howitzer		1 4 9¾		40	..	2	..	1	1	2	..	..	..	..	..	6	..	6	more 1-7th		
7th	13	do. do.		1 8 7½		20	1	..	..	..	1	..	..	..	..	..	..	2	..	2	1-10th		
		10-inch do.		2 0 10¾		30	2	1	2	1	2	2	1	..	..	..	..	10	1	11	more 1-3rd		
8th	14	do. do.		1 10 9¾		30	3	1	3	3	2	1	..	..	..	..	..	13	..	13	more 2-5ths		
11th	20	68 carronade wt. shot		1 4 9		40	2	3	2	4	1	2	2	..	..	..	..	14	2	16	2-5ths		
15th	26	4-inch iron mortar		1 11 10		40	..	5	2	1	2	1	..	..	..	..	..	11	..	11	more 1-4th		
		Total—not exceeding 10¾° elevation at 500 yds. range	500	..	..	240	10	12	10	12	9	9	4	..	..	..	..	62	4	66	more 1-4th	1-16th	
		Total—not exceeding 11½° elevation		..	..	487	23	29	21	24	18	21	4	1	..	..	..	136	5	141	more 2-7ths	1-28th	1-97th
12th	Aug. 21	8-inch iron mort	400 yards.	1 0	15 elevation.	20	..	..	2	..	..	2	1	2	4	..	..	4	7	11	more 1-half		
13th	22	do. do.		1 0		40	1	2	..	2	..	1	2	1	1	2	..	6	6	12	3-10ths		
17th	28	8-inch iron howitzer		0 11		50	5	2	4	2	1	7	1	1	1	..	..	21	3	24	near 1-half		
22nd	Sept. 16	do. do.		0 11		30	1	..	2	3	1	..	2	1	2	..	1	7	6	13	more 2-5ths		
23rd	17	16-inch do.		1 3		30	..	..	1	1	1	2	1	3	2	..	2	5	8	13	more 2-5ths		
24th	18	do. do.		1 2		30	..	..	1	4	1	..	1	1	2	..	3	6	7	13	more 2-5ths		
20th	3	68-pdr. carron. wt. shot		0 11		40	3	1	3	4	..	2	1	..	2	..	..	13	3	16	2-5ths		
25th	19	do. do.		0 13		30	..	1	3	1	3	1	..	1	..	3	..	9	4	13	more 2-5ths		
		Total—at 15° elevation and 400 yards range	400	..	15	270	10	6	16	17	7	15	9	10	14	5	6	71	44	115	near 3-7ths	near 2-5ths	
14th	Aug. 23	8-inch iron mortar	500 yards.	1 5	15 elevation.	40	1	1	1	1	..	..	3	3	..	1	1	4	8	12	3-10ths		
18th	29	8-inch iron howitzer		0 14		40	..	..	2	1	4	1	3	1	..	..	..	8	4	12	3-10ths		
28th	Sept. 24	do. do.		0 14		30	1	..	..	..	1	..	..	..	2	..	1	2	3	5	1-6th		
27th	25	10-inch do.		1 8		30	2	..	..	..	2	3	2	1	2	1	1	7	7	14	near 1-half		
19th	2	68-pr. carronade shot		0 13		40	1	1	..	2	..	2	3	2	2	1	..	6	8	14	more 1-3rd		
26th	20	do. do.		1 0		30	1	1	1	1	1	1	..	..	..	..	1	6	1	7	near 1-4th		
		Total—at 15° elevation and 500 yards range	500	..	15	210	6	3	4	5	8	7	11	7	6	3	4	33	31	64	more 3-10ths	near 1 half	
		Total at 15° elevation	..	..	..	480	16	9	20	22	15	22	20	17	20	8	10	104	75	179	near 3-8ths	near 3-7ths	5-32ds
		Total	..	..	..	967	39	38	41	46	33	13	24	18	20	8	10	240	80	320	about 1-3rd		

The two first days being considered preliminary, their practice is not included in the preceding table.

Of the foregoing 967 rounds, only 144 fell short; and of the 503 rounds remaining unaccounted for, it was considered that all except 37 would have struck the bastion in rear of the wall, if, according to the arrangement of Carnot's system, such work had been constructed there.

The foregoing experiments having proved that shot or shells could be fired at angles of 15°, so as to strike the wall, even at its foot, it remained to be determined whether, when so fired, their momentum was sufficient to breach it, the small charges necessarily used to attain the first object rendering this doubtful.

A portion, 30 feet in length at bottom and 28 at top, of a wall corresponding to that proposed by Carnot, was accordingly built with bricks in the summer of 1823. It was 21 feet high, 6 feet thick at top, 7 at bottom, and had one loop-hole in a recess; to support which, in continuation, it was strengthened by a buttress 4 feet square at each end, the whole carefully built, and well cemented. An earthen counter-guard was thrown up in front, and a mound in rear, the former being at the distance, and having the same section, as that proposed by Carnot, the latter represented his bastion, being at the same distance, but was only carried up 4 feet higher than the wall, and was therefore 8 feet lower than that proposed by him.

On the 5th of August, 1824, a year after the completion of the wall, eight 68-pounder carronades, in battery 500 yards from the crest of the counter-guard, three 8-inch and three 10-inch iron howitzers, at a distance of 400 yards, in all 14 pieces, fired 100 rounds each in about six hours, the howitzers firing live shells filled with powder, and the carronades solid shot.

A practicable breach, 14 feet in width, was made by their fire, and the buttresses were much injured.—*Fig.* 3 and 4, *plate* 1.

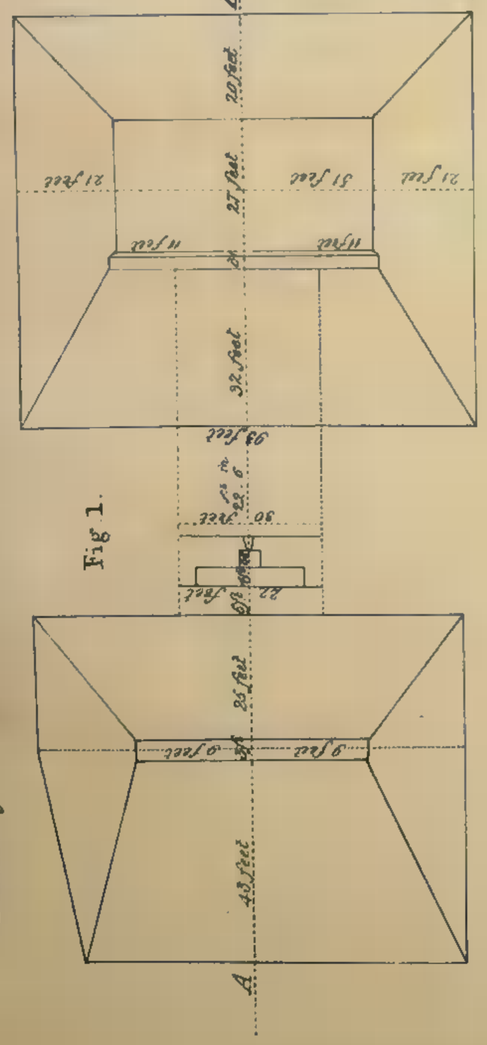
The splinters of the shells proving inconvenient to the men in the nearer battery, the loading of the shells was diminished.

On the 6th August the firing recommenced from eight 68-pounder carronades, at 500 yards; two 8-inch iron howitzers, and four 10-inch ditto, at 400 yards: 50 rounds per piece were fired in two hours, when the breach was examined, and found to be complete in every respect, and the buttresses to be in the ruinous state shown by the darker shade of *fig.* 3, and also by *fig.* 4, *plate* 1.

On the 5th and 6th August, two of the 8 and two of the 10-inch howitzers,

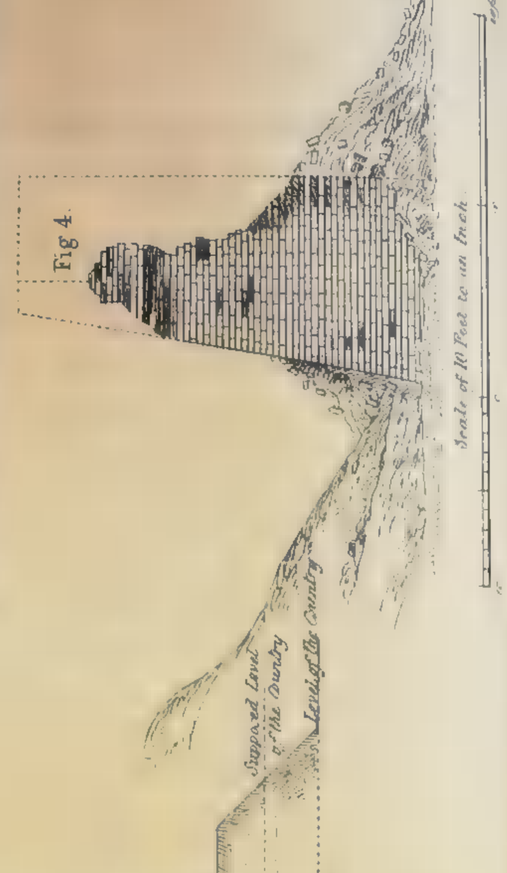
DRAWINGS *to illustrate the* PRACTICE *against* CARNOT'S WALL, *carried on at* WOOLWICH *by order of His* GRACE *the* MASTER GENERAL *in Aug.t* 1824

PLAN of the RAMPART, WALL, and COUNTERGUARD.

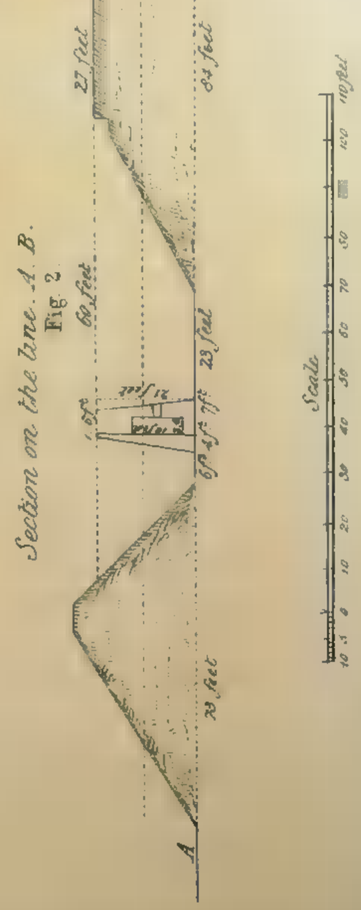


Front View of the Wall showing the effect of the 1st & 2nd days fire.

Side View of the Wall after the Second Days fire.



Section on the line A B.



and four of the carronades, had been placed on high traversing platforms, so as to raise them nearly to the natural level of the country, according to Carnot's system; but his Grace the Master-General, who examined the breach at this period, having given directions that all the ordnance should be placed on common platforms, the use of the traversing platforms was discontinued. It had previously been observed, that no advantage or superior accuracy of fire attended raising the guns.

His Grace also ordered that the rubbish should be cleared from the breach; and it was found that the wall was about 5 feet in perpendicular height in front, with a rounding of rubbish of about $2\frac{1}{2}$ or 3 feet on the top, and about $8\frac{1}{2}$ or 9 feet in height towards the rear.—*Fig.* 5, *plate* 2.

On the 11th August the batteries recommenced their fire from eight 68-pounder carronades at 500 yards, and six 10-inch howitzers at 400 yards, when 85 rounds from each howitzer, and 100 from each carronade, were fired in three hours and a half, by which time the wall and buttresses were one mass of ruin. —*Fig.* 6 and 7, *plate* 2.

The charge of the shells had been so much reduced, to avoid splinters reaching the batteries, that a considerable number did not burst.

From careful observation, it appeared that about one-fourth of the shells and one-fifth of the shot struck the wall.

The increased rapidity of the fire is remarkable, that of the third day being nearly double that of the first, although the reduction in the height of the wall, from 21 to 5 feet, rendered the operation obviously more difficult. A sketch of the counter-guard, *fig.* 2, shows the effect of the shells on its superior slope.

NOTE FROM JONES'S "JOURNAL OF SIEGES."

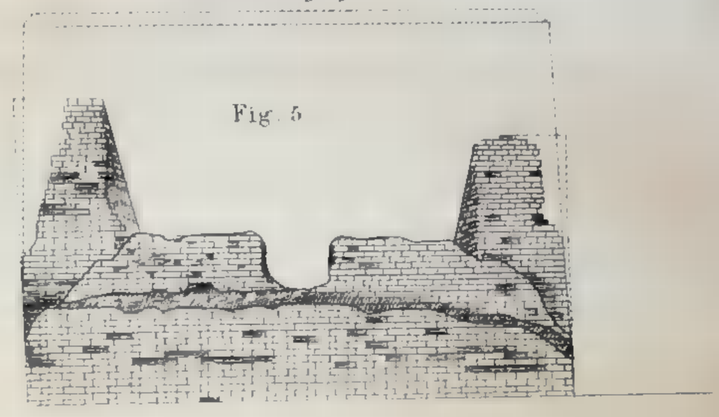
Circumstances will sometimes occur, that a place may be taken, by forming a breach from distant batteries, where neither time or means will admit of a more matured operation. Such, for instance, were the captures of Monte Video and Ciudad Rodrigo; and it is to be hoped, that whenever such chances again offer, similar enterprise on the part of the British commanders will induce similar chivalrous attempts, and be crowned with similar success. Therefore it may be useful to endeavour to form some rough calculation, from the experience of these sieges, of the time required to form a breach of given dimensions, with given means, from given distances.

DRAWINGS *to illustrate the* PRACTICE *against* CARNOT'S WALL.

Carried on at WOOLWICH *by order of His* GRACE *the* MASTER GENERAL *in Aug^t 1824.*

Front View of the WALL when the rubbish was cleared away from the BREACH after the Second days fire

Fig. 5



Front View of the WALL after the third & last days fire

Fig. 6

Side View of the WALL after the third days fire

Fig. 7.

General View of the Counterguard in front of the WALL after the last days fire

Fig. 8.

Referring to the Journals we obtain the following facts:

	Sieges.	Measurement of Breach thoroughly accessible.	No. of Shot fired.	Distances of Battery from Breach.	
1812.	Christoval	15 Feet	1600	450 Yards.	
	Badajos, principal breach	180	14,000	540	
	Ditto flank breached	100	9500	530	Wall casemated.
	Ditto curtain	40	3000	545	Bad masonry.
	Ciudad Rodrigo, principal breach	105	6700	560	
	Ditto lesser breach	30	2020	570	Bad masonry.
1813, July.	St. Sebastian, principal breach	100	13,000	620	Average distance of batteries.
	Ditto lesser breach	30	5000	620	Ditto.
August.	Ditto addition to breaches	330	41,000	520	Ditto.
		930	95,820	4955	

Taking the average of these nine operations, we find that a breach of 103 feet (being an opening sufficiently great to warrant an assault) can be made practicable by the expenditure of 10,653 shot from the distance of 550 yards. Now, assuming the rate of firing at 20 rounds per hour, that expenditure will occupy 532 hours firing of a single gun, or 35 hours firing of a battery of 15 guns, which number is selected as being about the average force of the batteries at the above operations.

This calculation being assumed as correct, to find the time required for making a breach from the same distance, with any other number of guns, becomes merely a simple rule of proportion; it being however observed, that some addition to the periods must be made when the guns are fewer, and some deduction when they are greater, it being invariably found in breaching, that the more numerous the engines employed, the greater is their proportional effect. The above calculated periods for forming breaches may be much abridged, by the free use of 10-inch shells filled with powder, to be lodged in the clay behind the wall, as soon as the masonry gives way.

The effect of shot fired for this purpose was observed to be very inconsiderable, many of them serving apparently only to ram the clay more firmly; while the shells from the garrison, which fell into the parapet of the trenches, frequently in their explosion blew away a considerable portion of the parapet, or made large and deep holes in the solid ground.

It may not be without its use to observe, that the quantity of ammunition necessary for forming a breach in the ordinary defensive walls of Spain and other southern countries, is far greater than in those of northern countries, as the cement used in their construction, after a few years, attains a solidity surpassing that of the stones which it unites; and the consequences are, that walls built with moderate sized, or rather with small rough stones well bedded, and their interstices well filled up with mortar, become so completely one body, and so incapable of being split into large pieces, that they can only be brought down from distant batteries by being literally pounded into small particles. It would not perhaps be too much to assume, that double the means would be required to breach such a wall, over those necessary to breach the ordinary brick revetements of France and Flanders.

From the foregoing papers it appears, that a breach about 100 feet wide may be rendered practicable by batteries at a distance of 500 yards, by the expenditure of about 10,600 24 lb. shot, firing with a full charge. That from about the same distance it requires 5600 68 lb. shot, and 4200 8 and 10-inch shells, fired à ricochet, to make a breach of the same width, when the scarp is covered by a counter-guard, as proposed by Carnot: and that from a battery placed on the crest of the glacis, about 310 24 lb. shot, and 30 or 40 8-inch shells, will produce the same effect. The weight of shot therefore expended in forming a breach under these different circumstances will be as below.

Distance.	Fire.	No. of Shot.	No. of Shells.	Total Weight of Iron.
Yards.				
500	Direct	10,600	....	254,400
500	Ricochet	5,600	4,200	660,100
50	Direct	310	40	9,040

The disproportion between the direct and ricochet fire would have been more glaring still, had guns of the same calibre been used on both occasions, for the effect of one 68 lb. shot would be far greater than that of the three 24 lb. shot, fired at the same angle, and the 8 and 10-inch shells used in the ricochet practice were probably more effective than shot of the same weight.

W. D.

VIII.—*Memoir on the Fortifications in Western Germany, compiled from various sources.*

Observations on the German Frontier of the Rhine.

The States of Germany having entered into arrangements for the further security of the Frontiers of the Rhine; Cologne, Coblenz, and Mayence, have been strengthened, that they might be always available as centres of operations, and as grand military depôts. It was contemplated, that the country in front of this line would be covered to the north by the Belgian fortresses (having Juliers in their rear), and by the very rugged territory of Luxembourg, which town is still occupied by a Prussian garrison. To the south, the defence of the river Saar has been improved, particularly at Saar Louis and Saar Bruck, from whence the country is full of defiles to Landau, on the Queich. This river crosses the plain to Germersheim on the Rhine, at which point there are to be strong fortifications.

As the French hold one side of the Rhine to some distance below Strasbourg, the tête-de-pont of Germersheim would be very formidable to any advance they might make on the right bank; and to prevent their advance into Germany by the defiles of the Black Forest, very extensive works are to be constructed at Ulm on the Danube, which would be then available as a military depôt and centre of operations. The French contributions of 1815 are devoted to these arrangements; but the Prussian proportion has been made over entirely to that government: the expenditure of the remainder is regulated by the Diet at Francfort, to whom there is a committee of engineers attached. As yet the Diet have only expended the interest of this money, but the Prussians have laid out much larger sums.

Coblenz.—Coblenz contains about 12,000 inhabitants. The new enceinte being much larger than the old, there is a considerable vacant space, part of

which is now laid out in streets; but that near the river is reserved for military purposes. The garrison generally amounts to 11,000 men.

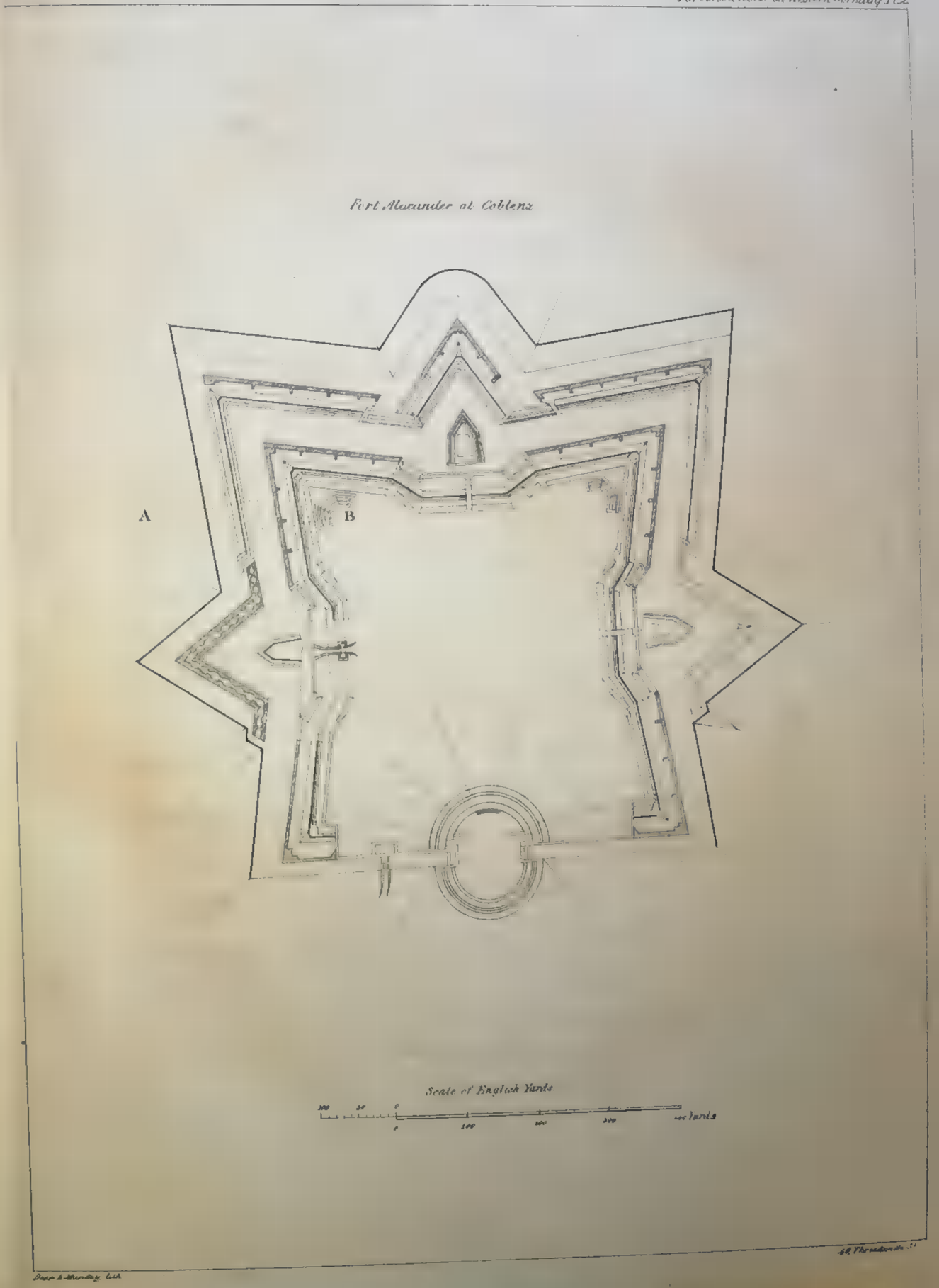
Strangers are at present restricted from seeing any of the works with the exception of Ehrenbreitstein; but this order is now of little use, as the details are generally known to the engineers of other countries. It is indeed well ascertained, that three French officers worked at them as masons for several months. Plans of Coblenz were obtained from three foreign officers; they differed in some of the minor points, but the most accurate is shown in *plate* 1.

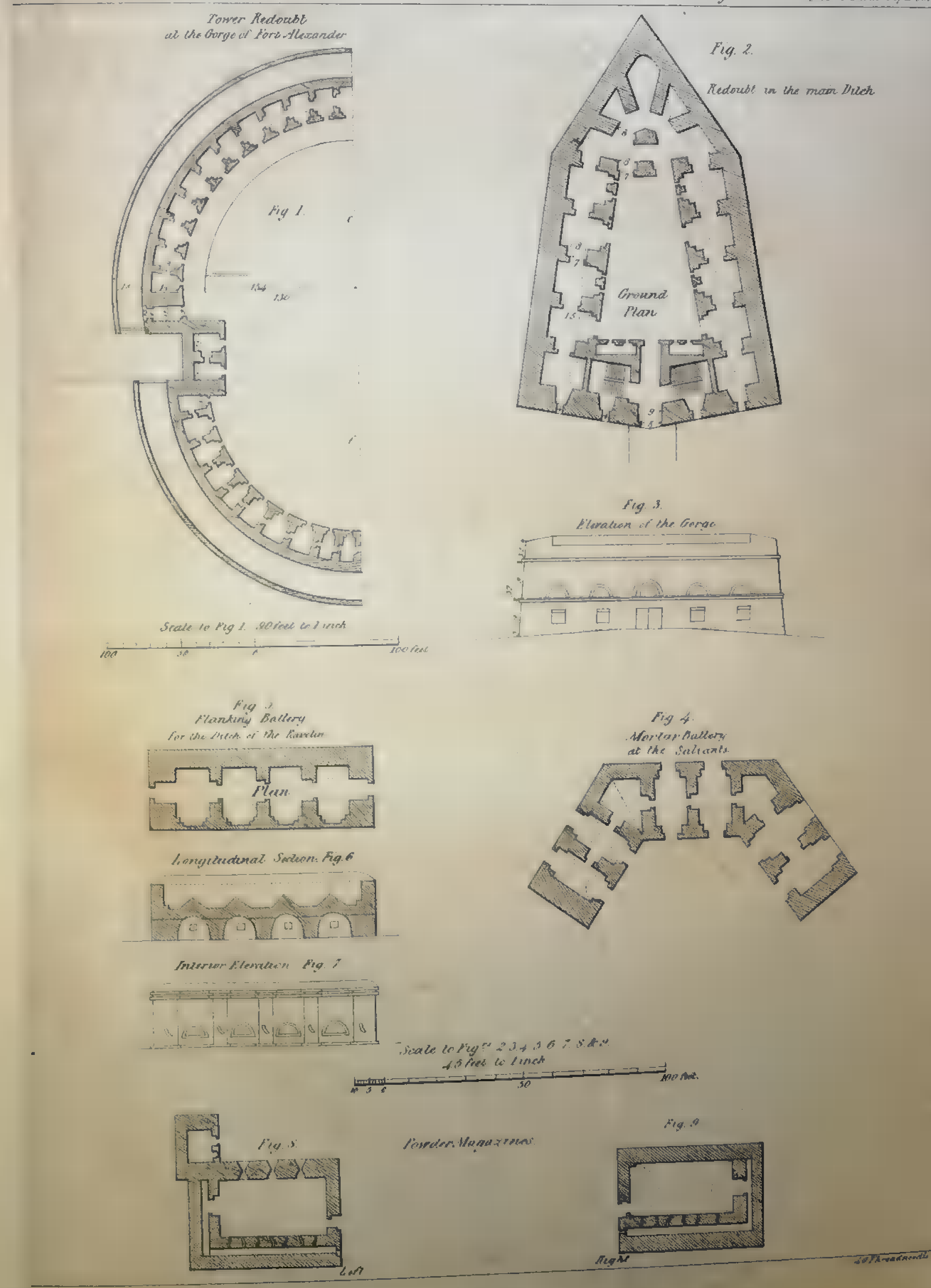
It is to be observed, that foreign officers take a degree of interest in new fortifications and military projects, not generally felt in this country; and although they are not disposed to give any information respecting their own works, yet as to those of other powers they are far less reserved. A more accurate knowledge of places may be generally thus acquired, than by endeavouring to procure the details by personal observation. The following information has been principally obtained by the exchange of memoranda on such subjects.

Ehrenbreitstein.—The castle of Ehrenbreitstein, called also the Fort of Frederick William, has been reconstructed since 1815. The casemates are fully equal to contain the men, provisions, and stores required for the most protracted defence. They also protect the head and machinery of the inclined plane, communicating with the work below, in which there is a harbour for barges. They contain a double tier of embrasures on the side opposite to the Rhine, commanding the heights of Azimeer: the narrow glacis in front is countermined, and the two advanced works are also said to be so. The escarps, in every part of the enceinte, appear to be at least 35 feet high, except where the rock is precipitous.

Pfaffendorfer-height.—The Pfaffendorfer-height is occupied by a work resembling in its details that of Kaiser Franz (*plate* 4), and by two smaller redoubts. The oblong tower between this height and Ehrenbreitstein, which was constructed this year, to enfilade the valleys of the two small rivers, has two tiers of guns in its casemates, and its general construction appears to resemble that of edoubt, *fig*. 6. *plate* 5.

Fort Alexander, plate 2.—The outline of Fort Alexander is taken from the project of Montalembert, called the Fort Royal, but the details are more simple, and are adapted to the escarps of Carnot. It may be considered objectionable in this construction, that the counter-guards are only flanked by one tier of four guns: as, when this fire is overcome, they would afford places of lodgment to




Tower Redoubt
at the Gorge of Fort Alexander
Fig. 1.
Scale to Fig 1. 90 feet to 1 inch
100 feet
Fig. 2.
Redoubt in the main Ditch
Ground Plan
Fig. 3.
Elevation of the Gorge
Fig. 5
Flanking Battery
for the Ditch of the Ravelin
Plan
Longitudinal Section Fig. 6
Interior Elevation Fig. 7
Fig. 4.
Mortar Battery
at the Salients
Scale to Figs. 2 3 4 5 6 7 8 & 9
45 feet to 1 inch
100 feet
Fig. 8.
Powder Magazines
Fig. 9
Left
Right

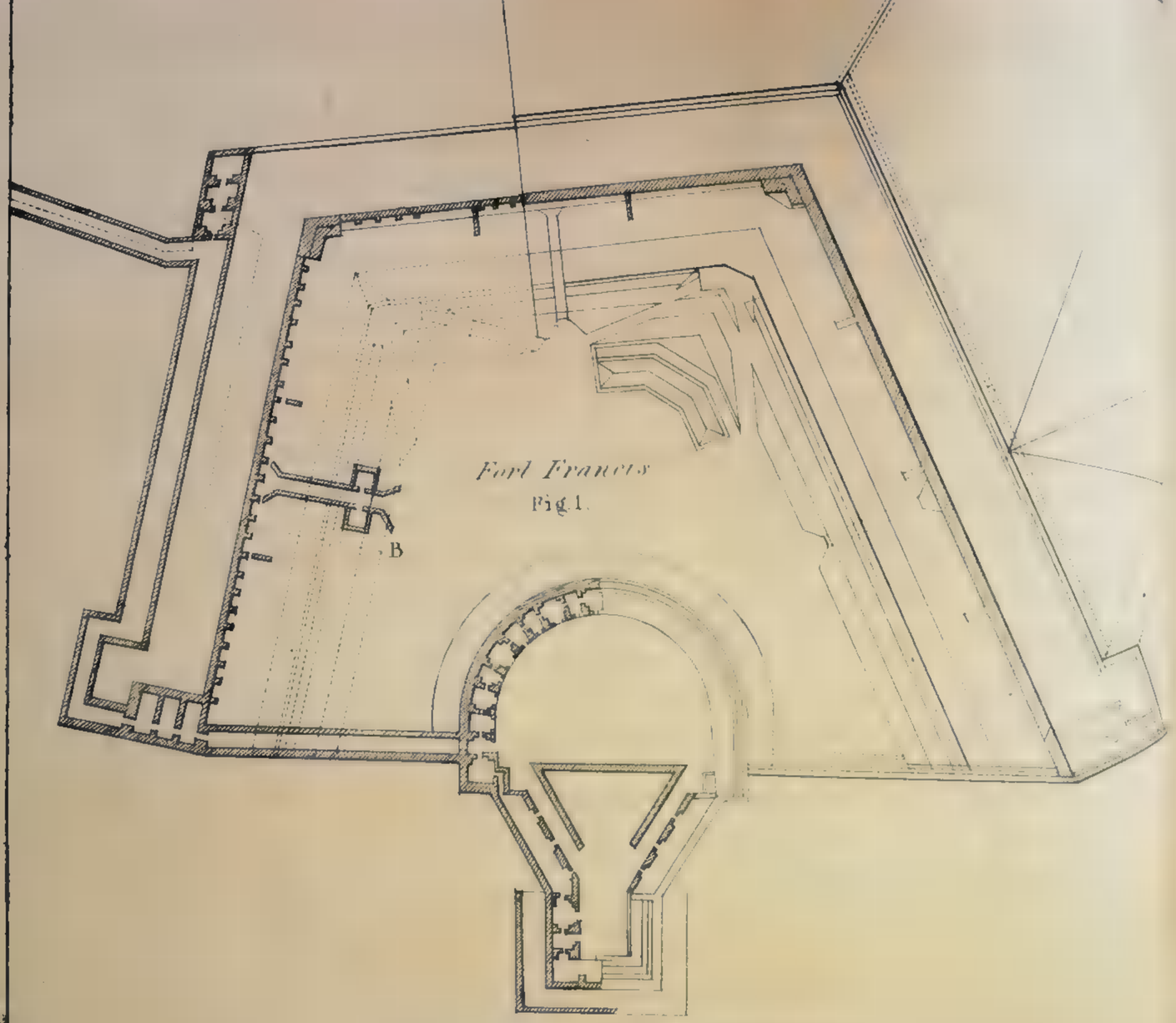


Fig. 1.

Scale to Plan 120 Feet to one Inch.

Fig 2.

Section on AB. of Fort Alexander.

Scale 45 Feet to one Inch

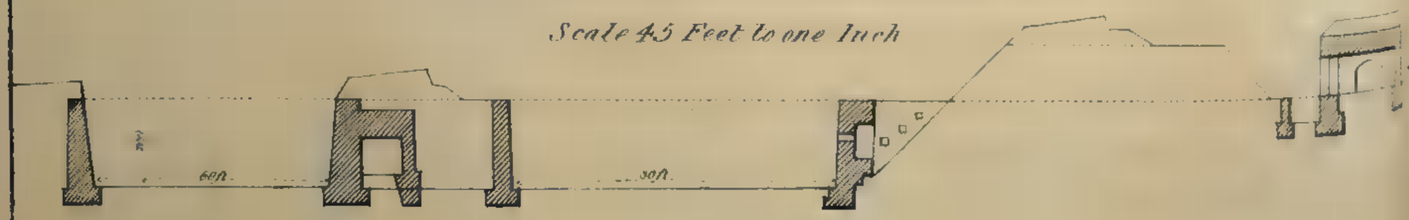
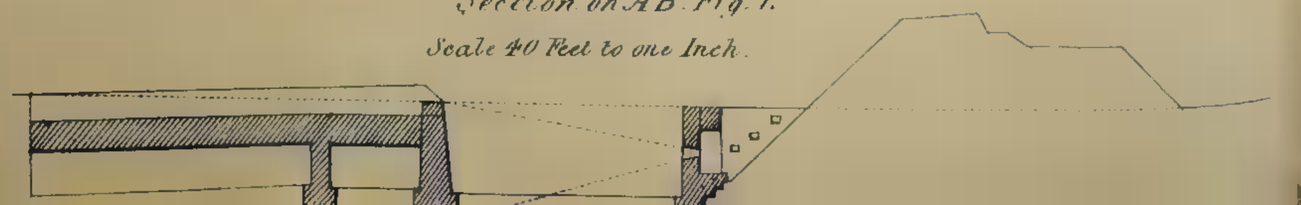


Fig 3.

Section on AB. Fig. 1.

Scale 40 Feet to one Inch.



secure the passage of the main ditch, which has a flank of two tiers of five guns each.

There is a good glacis in front; but the steep ground on the sides and rear is only protected by the guns of the town, and by those of the adjoining works of Fort Constantine (of which the projecting part has two tiers of embrasures), and a tower of Montalembert's projection, but apparently smaller than the diameter of 75 feet, as recommended. A subterraneous passage between Forts Alexander and Constantine was completed in 1830.

Enceinte of the Town.—The town forms a centre for the support of the surrounding works, and is secure from a coup-de-main. The rampart, having obtuse angles, is little subject to enfilade, and the Carnot escarp is well covered: but the town, being commanded from the sites of the works, would be greatly exposed after their loss to an enemy's fire. It appears, that even now, an attempt might be made to annoy the town from the Pfaffendorfer-height, by an enemy strong enough to resist the sorties of the garrison.

Fort Franz, plate 4.—Fort Franz, and the smaller outworks between the Rhine and the Moselle, being commanded (with the ground in their rear) by Ehrenbreitstein, have been constructed on a less expensive scale than the works on the heights. They have a good command of the ground in front, and the tête-de-pont will give greater security to their communication with the town.

General Observations.—The commanding situation and height of Ehrenbreitstein gave it great advantages, which have been ably increased by the formidable works now completed. By its immense quantity of casemated fire, directed towards the heights, on the right bank of the Rhine, an attack on that side with the usual means would be hopeless: the other parts of its enceinte have been also strengthened, although the old works were considered to be too strong to reduce by force. Fort Alexander gives also a great degree of strength to the opposite side of the town; and the other outworks, having casemated keeps, are considered to be equal to resist the attacks of an enemy for a considerable time, when there is only the usual garrison in the place. But these works, being on the summits of eminences, would also afford shelter for troops drawn up close in their rear, and cover the communications to the town; they therefore, when the garrison is large, become fortified positions, affording great facilities to their offensive operations, and allowing the whole disposable force to be brought (in the event of a regular attack on a work) on either flank of the trenches.

These arrangements are principally attributed to General Von Aster, who

was much noticed by Napoleon, but has since entered the Prussian service. It is stated that the first project of securing the site of Fort Alexander, by a line of towers, was abandoned through his representations.

Cologne.—Cologne contains about 50,000 inhabitants. It is the seat of Government for the Prussian provinces of the Rhine, and the head-quarters of a division consisting of about 25,000 men.

Plate 6.—The works have been carried on since the war by small parts, as a regular annual expenditure. The old enceinte has been thus repaired, where ruinous, to make it available against an escalade. The alternate bastions of the earthwork in front have been strengthened by a casemated keep, having three guns in each flank, with a caponière communication across the intermediate ditch, and the whole line appears to be well kept up.

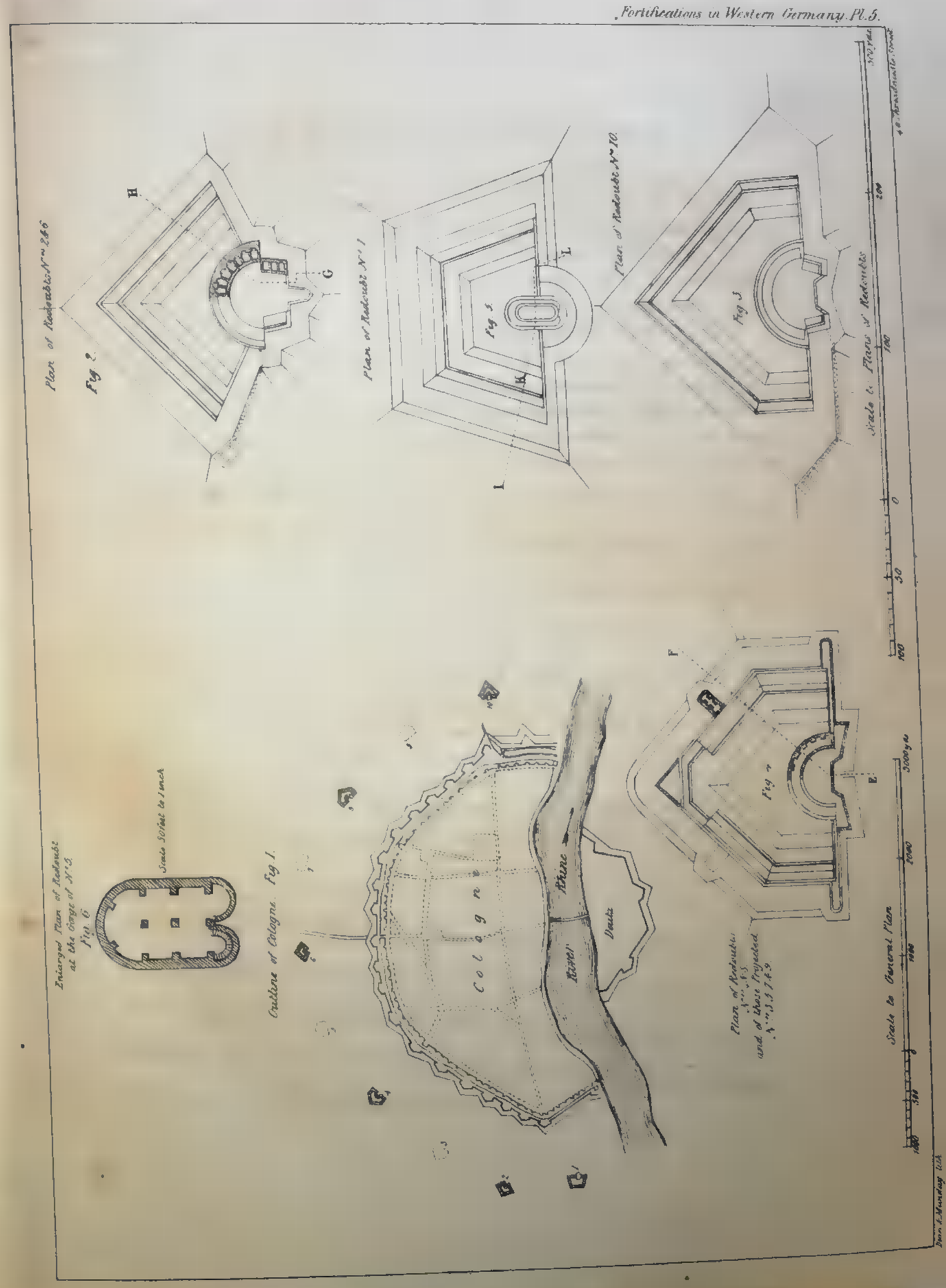
Plate 6.—The enceinte of Deütz has been altered from the old work, the alternate bastions having been strengthened by a casemated barrack across the gorge, and the rampart between formed into a plain salient angle.

New Redoubts.—Redoubts have been projected since 1815, at the distance of about 600 yards from each other, forming a line about 500 yards in advance of the place. The following sketches have been collected, showing the gradual improvement that has taken place in this description of work, which, from a slight external inspection, appear to be generally correct.

Plate 5.—The redoubts first constructed are shown in *fig.* 2. They appear objectionable from the profile having been made so high (in order to secure the keep from distant fire) as to leave several feet of the escarp exposed, the earth from the ditch not being sufficient for the glacis, which remains incomplete: this defect has been in some degree concealed, by trees being thickly planted round the work. The sketch being erroneous in this point, probably shows the proposed remedy.

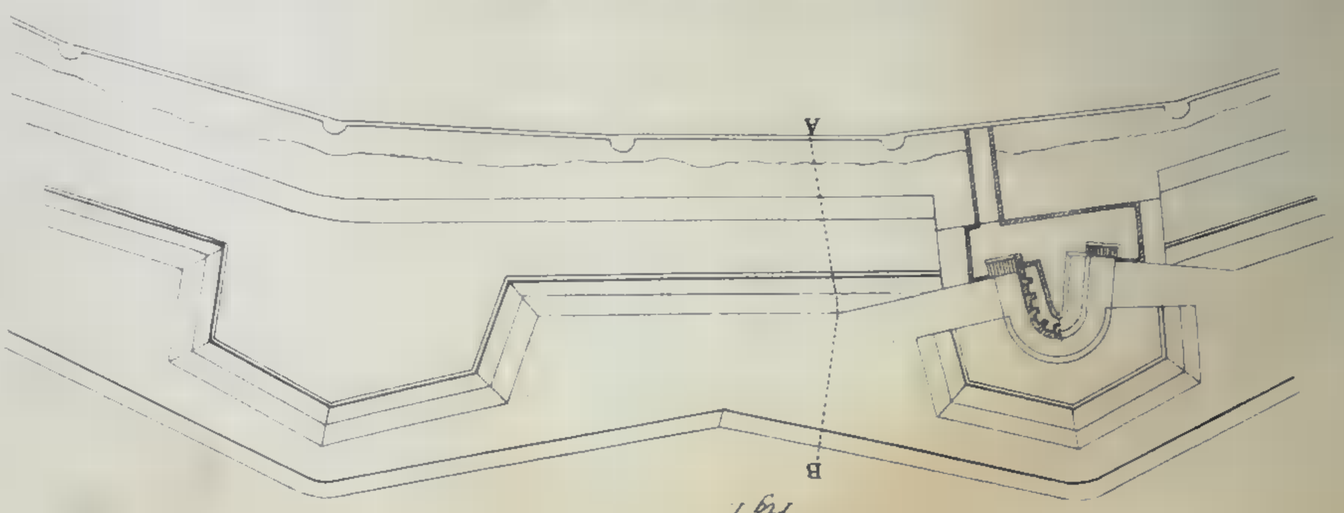
The details of a redoubt, constructed about a year or two subsequently, are shown in *fig.* 3. The profile is nearly as in the former redoubts; and, consequently, the sketch has a similar error to the last.

To redoubts of a yet later construction, the following general description will apply. It appears from the sketch, that the salient angle is enclosed by a Carnot wall, forming an area, from which a gallery descends to the counter-mines under the glacis: this area also protects three mortar casemates, which are directed on the capital. The caponière, which flanks the ditch, is also protected by the musketry fire of the Carnot wall (from which it projects), as also by the rampart;



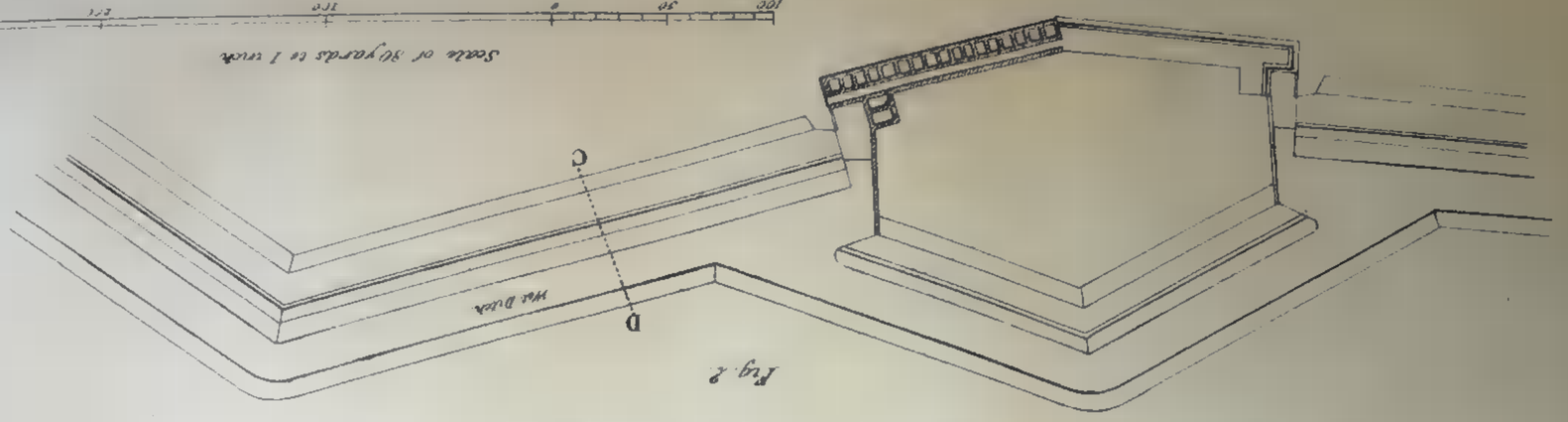
Entrenched Outline of a Front of Cologne

Fig 1

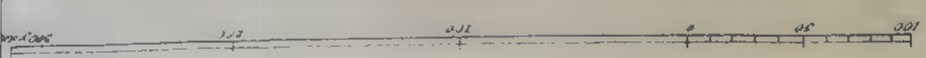


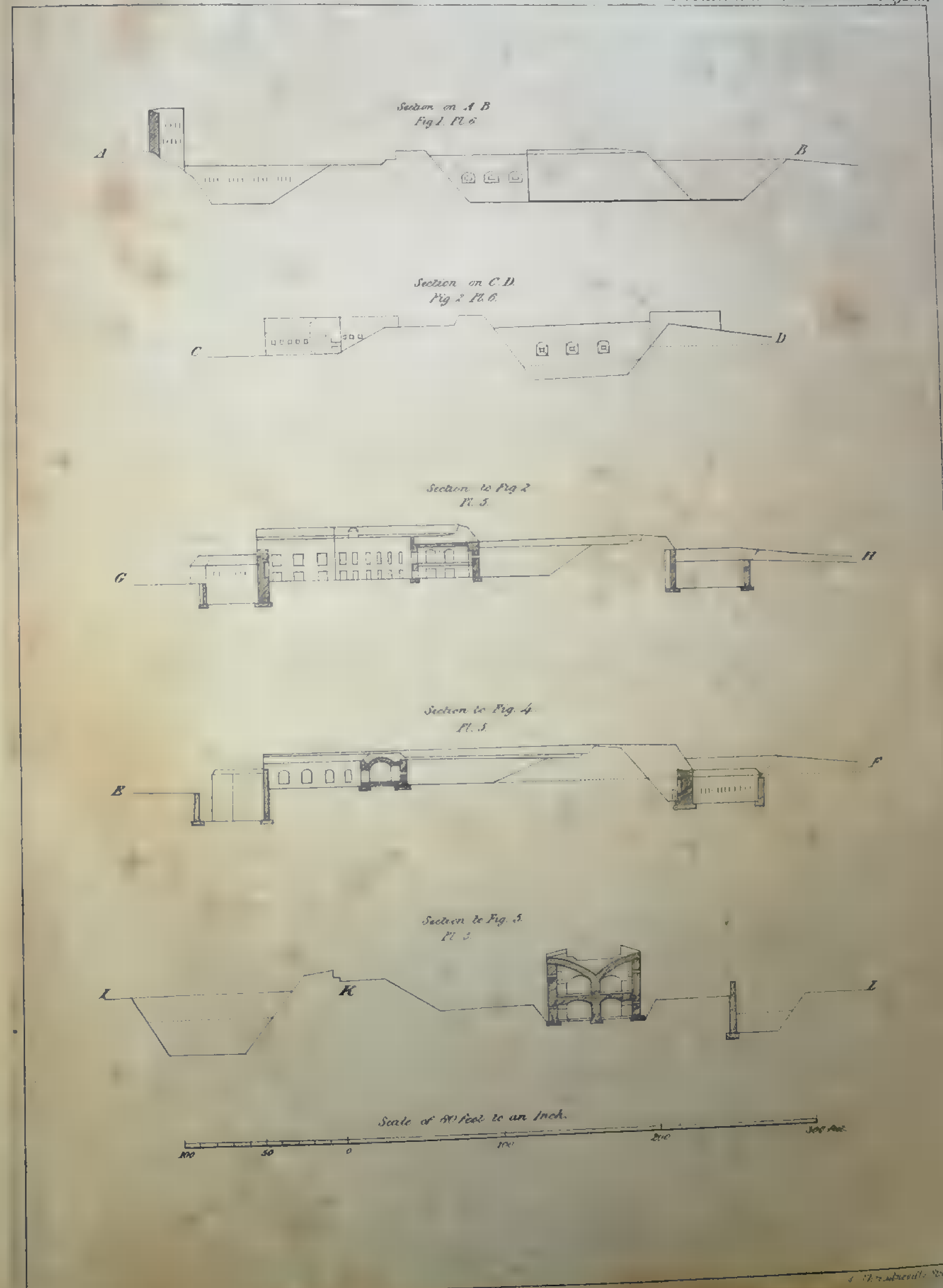
Entrenched Outline of part of Deutz

Fig 2



Scale of 80 yards to 1 inch





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and in the event of an enemy attempting to pass the ditch upon it, he has still to descend the wall, which is enfiladed in its rear. The circular keep is shown without flanks in the sketch, which is generally the case in these works. It appears also to show correctly the glacis as now formed.

Plate 5, fig. 5, a redoubt constructed with a wet ditch having no revetement: the slope of the rampart was planted with couch-grass at the time of its construction, which appears to answer very well. The enlarged plan and section of its keep show the internal arrangement, by which ▪ tier of embrasures, and two tiers of loopholes, with ▪ good vent for the smoke, can be obtained under the platform, at a comparatively small height.—See *plate* 7.

The country round Cologne being very flat, it would be advantageous, with a large garrison, to raise epaulements between the redoubts, which might be flanked by them both in front and rear. A line would thus be formed, which would cover any troops sent to assist the redoubts, either by their fire or by sorties, and which would not be of material service to the enemy after their reduction. The advantage of keeping the enemy thus at a distance by the redoubts, would be very great, as the old wall of the town is exposed, and the bastioned line in front is not adapted to resist an assault.

Mayence, plate 8.—Mayence contains about 20,000 inhabitants. Although in the state of Hesse Darmstadt, it is occupied as a fortress of the empire by a garrison of 13,000 men, consisting of Austrians and Prussians, in equal numbers. A military governor is appointed every three years by those nations alternately.

The interior enceinte of Mayence has had slight repairs required to place it in a serviceable state. The escarps are above 30 feet in height generally. A considerable depôt of stores was formed in the citadel, after the French revolution of June 1830, since which it is difficult to obtain admittance. The old works, which formed a kind of outer enceinte, have been demolished.

The works round Cassel are in earth, and have been lately repaired. The tête-de-pont in the interior is to be large and casemated: the foundation is built on piles. These additions are not shown in the sketch.

Fort Montebello is also of earth on the land side. The gorge (towards the river) is shut in by a cremaillered wall 15 feet high, in the centre of which is a casemated barrack, which is too small to contain the troops required, or to serve as a keep for so large a work. The whole has been lately placed in a serviceable state.

The new works, to replace the exterior enceinte round Mayence, have been laid out under the directions of the Austrian General Scholl, who, it appears, has been allowed so small a sum by the Diet, both for their construction and for the purchase of the land, that he has been obliged to follow, in a great degree, the tracings of some works constructed in 1793.

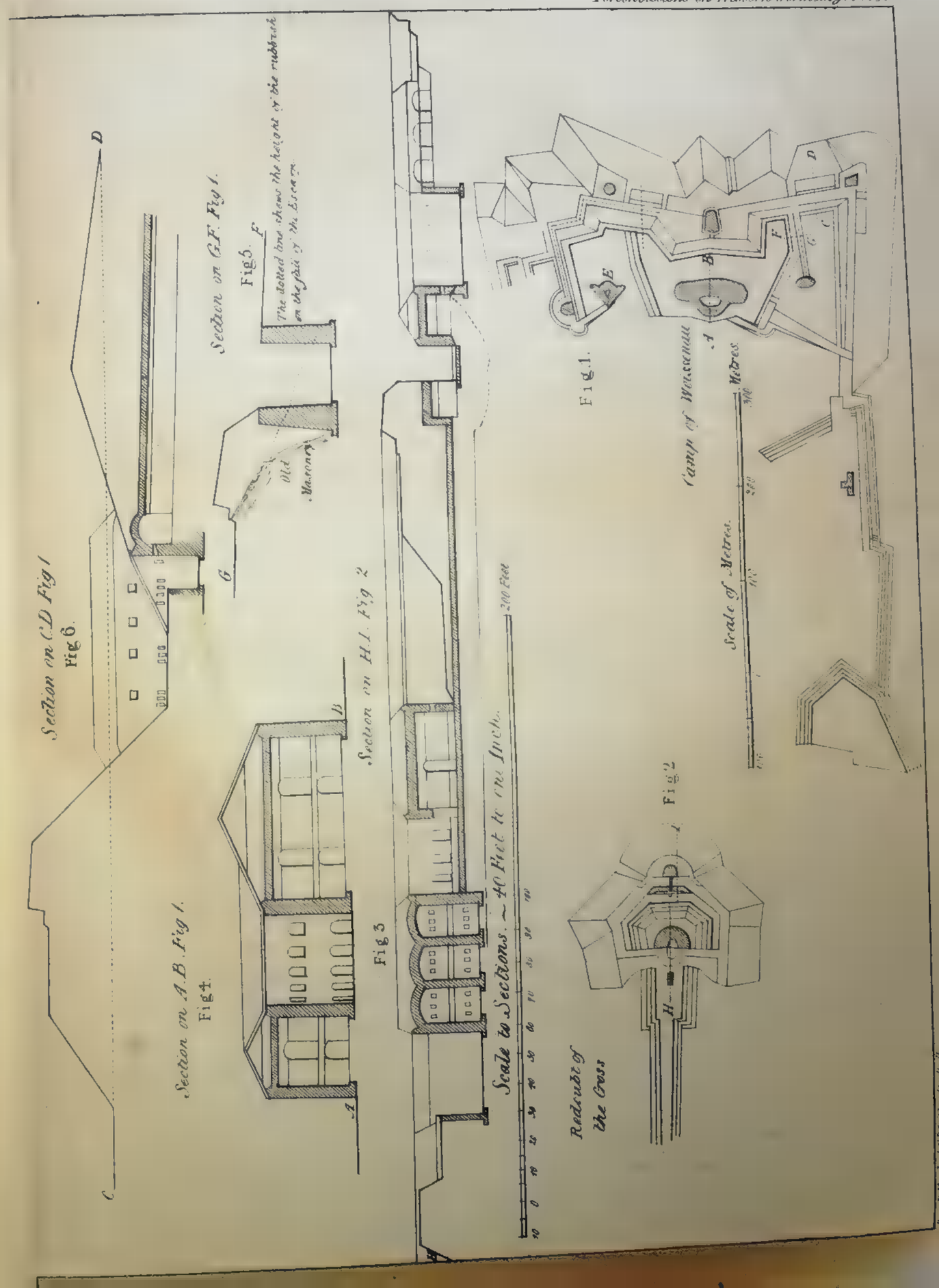
The Weissenau Lager (or camp) is nearly of the same outline as the old work. In its front the rampart is without revetement; but there is a loop-holed counterscarp, which also serves as a communication to the redoubts of the covert-way, and to the countermines, which consist of galleries directed straight to the front, from 200 to 300 yards in length, having occasional apertures in the sides for the heads of branches. Parts of the counterscarp are arranged for sorties, as shown in section *c, d,* (*plate* 9, *fig.* 6): they would require moveable platforms, which might be formed of palisades, with battens on the upper part. The troops descend into the front ditch by ramps (shown by dotted lines), which, being revetted on both sides, and enfiladed by the casemates (marked E), have no gates.

The redoubts command the counterscarp, the ascending planes of the sorties, and have a reverse fire on their ditches in their rear. The centre caponière enfilades the front ditch, and communicates directly with the gallery of the counterscarp, and with the large casemate in the interior of the work.

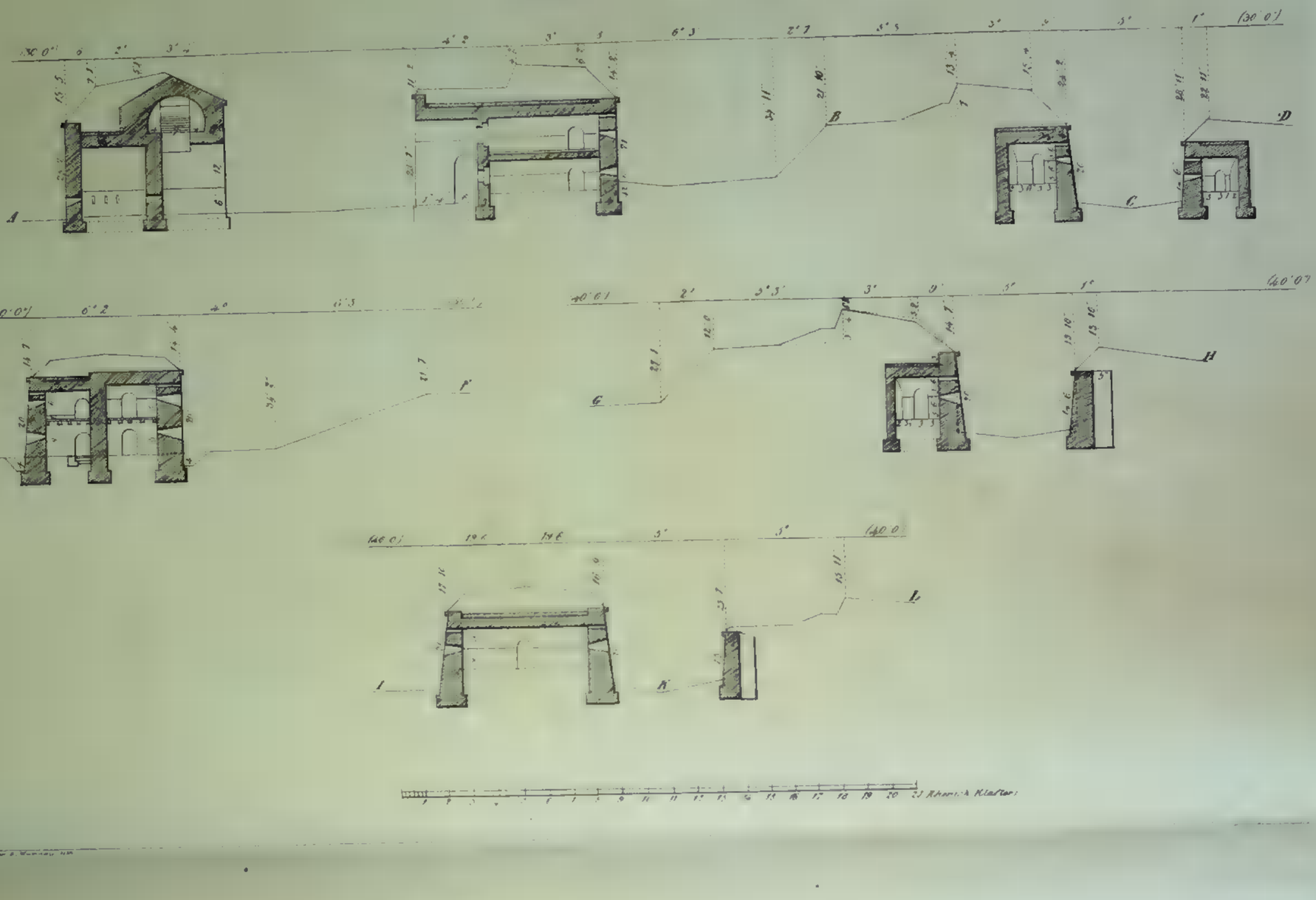
The whole of the casemates may contain on emergencies 2000 men, and the rear of the works enclosing them has been lately palisaded.

The section *e, f,* (*plate* 9, *fig.* 5) shows a revetement which gave way. It was 24 feet high, 6 feet thick at the top, and eight feet at bottom, without counterforts, being in front of an old wall. The parapet, 12 feet high, was made after the masonry had been built about two months, orders having been given to expedite the work. A number of men were ramming the earth of the parapet at the time, and nine men underneath the wall were killed by its fall.

Kreuz Schanz, plate 9.—The Kreuz Schanz (Redoubt of the Cross) is only flanked by caponières in the ditches at the front and rear, but the faces are partially seen by the redoubt in the covertway, and the flanks are protected at a distance by the enceinte of the town. The salient angle being cut off, and having an advanced casemated escarp, four mortars can be placed in arches under the parapet; and there is a musketry fire on the covertway in front. Four



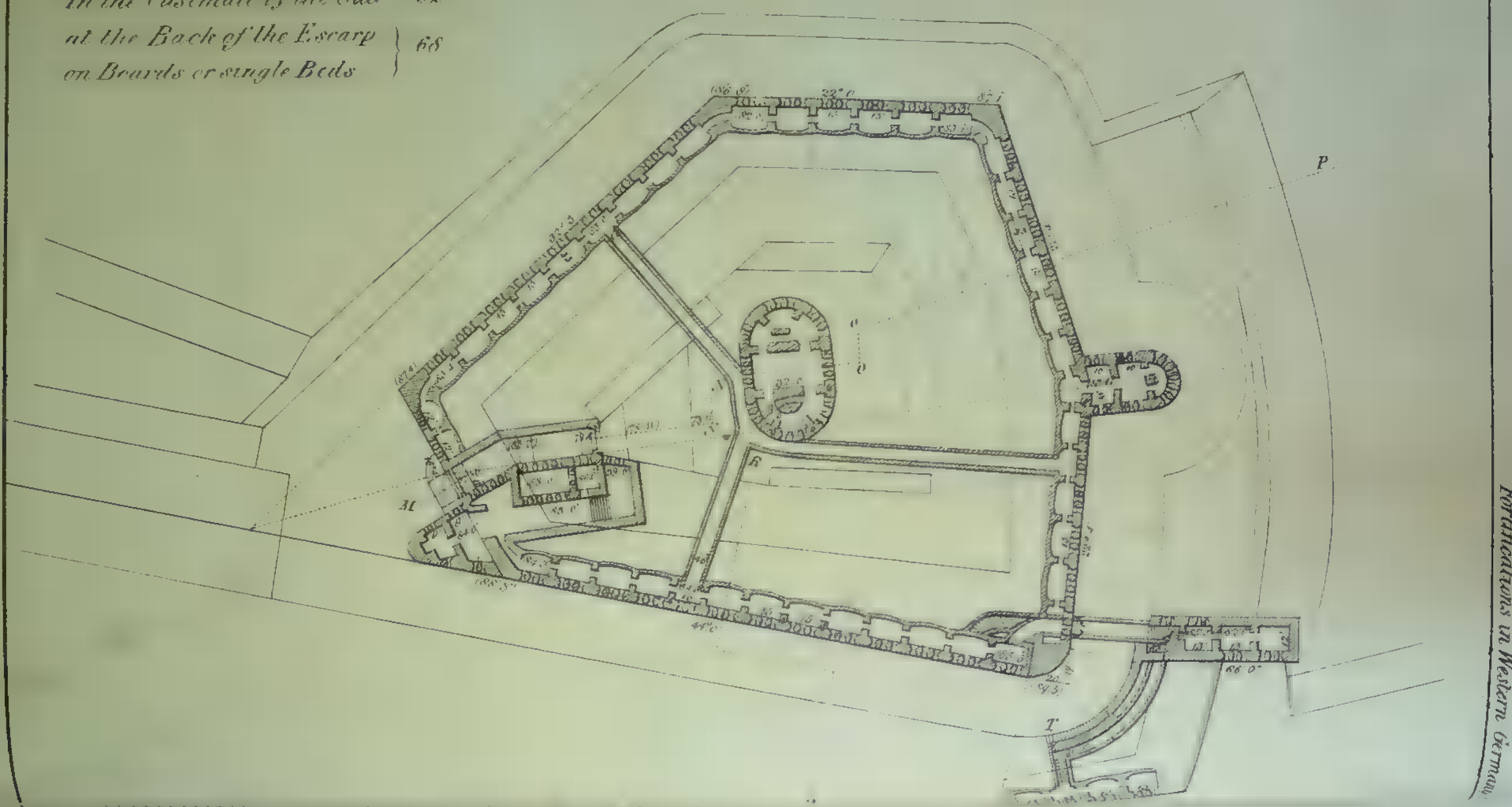
HARTENBERG. Sections to Plate 10



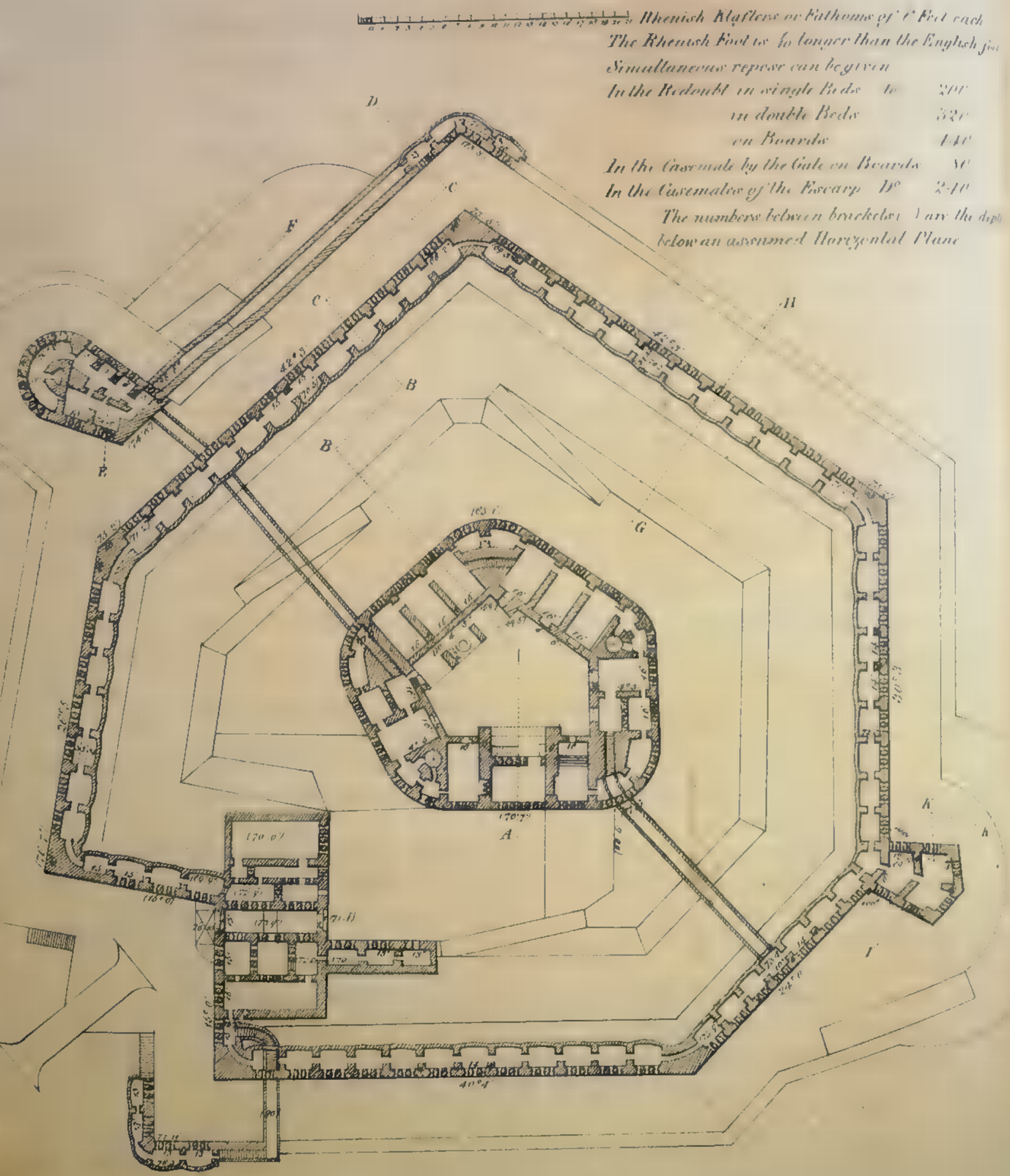
Hartenberg Redoubt, N.° 3.

Simultaneous repose can be given

In the walled Blockhouse	*40.*
In the Casemate by the Gate	*52*
at the Back of the Escarp on Boards or single Beds	*68*



Hartenberg Redoubt N°2.



galleries of countermines extend to the front, one of which is more than 200 yards long, but they are generally (as also those of the Weissenau Lager) only a few feet below the surface. The interior communications are commodious and secure to the casemates, which might contain on emergency about 300 men.

Between the Kreuz Schanz and Hartenberg redoubts, are five or six casemated block-houses, generally encompassed by a small work without flanks: they are very insignificant; their sites are *nearly* shown by marks on the plan.

Hartenberg Redoubt, plates 10, 11, 12, *and* 13.—The plans and sections of the two redoubts of the Hartenberg, are fully detailed by tracings from the official plans. The arrangements give great facilities for sorties. The escarps are well covered, except that in rear of redoubt No. 3, which is built near the edge of a steep bank, and is referred to on the plan. This redoubt does not appear to be of sufficient importance for its situation, the ground in the rear being only protected by the distant fire of the place, and the ditches in front being without flanks; the space within is also very confined, and the small number of troops occupying the work would not allow of sorties formidable to the force that must be engaged in the attack.

There is also a new work in progress on the right bank of the Rhine above the town, near the site of Fort Gustavus. Pile-driving was carried on there to a considerable extent in October 1831.

The Austrian Engineers generally prefer the construction of General Chasseloup, who has recommended the use of hollow escarps, detached caponières in the centres of fronts, and redoubts in the covertway for ditches requiring reverse fires. He was the first who proposed advanced ravelins, which were constructed at Alexandria. The confined nature of these works allow only of some details being shown of this system, and they have not been closely followed, as, in particular, the reverse fires are generally protected at the angles by redoubts in the system recommended.

Remarks on the Country on the left Bank of the Rhine.—With reference to the country in advance of the fortresses on the Rhine, a few observations are added, from information acquired, partly in visits made to some of the Belgian fortresses, to Juliers and Landau lately, and to Luxembourg at a former period.

The northern part, formerly considered the strongest, is now perhaps the most insecure, as in the event of the Belgian fortresses being at the disposition of France, an advance might be made on Cologne, the principal road only being

protected by Juliers, an old fortified town, principally depending on the strength of a square citadel and large outwork, which have been lately repaired.

Luxembourg.—The adjoining country of Luxembourg is exceedingly rocky and broken, the roads lead through the capital, which is very strongly fortified, and has a large Prussian garrison well found in stores and provisions; but, from the defiles near, it may be easily blockaded.

Trèves.—Trèves is in a great degree protected by Luxembourg, but, as it may be attacked by an army following the rivers Saar and Moselle, it is generally understood that it will be made defensible by outworks on the surrounding hills.

Saar Louis and Saar Bruck.—The river Saar is then considered to be a line of defence as far as the rugged country extending to Landau. It is protected by Saar Louis, a small strong town, which has been lately placed in a state of defence, and Saar Bruck, containing 5000 inhabitants, which has considerable fortifications, two large outworks having been added, which with the stores and garrison are complete.

This latter town commands the entrance of a road, made partly through a rough mountainous country, for about thirty-five miles, which is the communication between Metz and Mayence: it was improved at a great expense by the orders of Buonaparte. But the town may be avoided by an army making a detour by Deux Ponts, which however would be attended with considerable risk, against even an inferior force, as Saar Bruck must be masked, and the road passes through continued defiles to the plain of the Rhine.

Landau.—Landau, belonging to Bavaria, contains about 6000 inhabitants, and a garrison of 5000 men. The mountainous country extending from Saar Bruck here becomes more level. By sluices on the small river Queich, a large part of the town can be covered by inundations. The fortifications are Vauban's second system: they are in a very serviceable state. A bomb-proof covering of timber and earth, protected from the weather by a tiled roof, has been lately given to the tower bastions, and two redoubts are projected for the high ground (above the Camichon outwork) which commands the town, and would probably be the side of attack.

Germersheim.—The river Queich will be also of great importance to the new fortifications at Germersheim: it crosses the plain in a parallel line to the Lauter, the French boundary, fifteen miles distant. The celebrated lines constructed by Vauban along this river, are still available after some repair to the sluices; but the town of Weissenburg at the head of the lines being weak, and

commanded from the adjoining mountains, the lines have been forced at that point, and do not now possess their former reputation.

Remarks on the Country on the Right Bank of the Upper Rhine.—In the event of the French crossing the Rhine at Strasbourg, and proceeding down the right bank, they would probably be opposed at the river Neckar, in which case their rear would be exposed to annoyance from troops, either crossing at Germersheim, or passing through the roads in the Black Forest. In the event of their attempting the latter route (to penetrate into Germany), they might be advantageously opposed at the gorges of the defiles from Ulm, where the principal roads of the country are concentrated.

Ulm.—This town lies between the Danube and some high ground, which has been long considered as most eligible for a camp. This height, which commands the town completely, and would prevent its making any effectual resistance, it is proposed to enclose, by extending the fortifications. Dams across a small river joining the Danube above the town will greatly strengthen that side, and the works generally will be flanked by a casemated fire from detached caponières.

Wurzburg.—Besides the towns under the direction of the Diet, the Bavarians have the large populous towns of Augsbourg and Nurembourg, which are surrounded by old walls, with a few modern works in front. Wurzburg, containing 17,000 inhabitants, is fortified, and has a small citadel on a steep rock. The town is divided by the river Mayn, and commanded so completely, as to render it incapable of any advantageous resistance against a serious attack, which could not be withstood more than a few days. The other defensible towns are Ingoldstadt and Passau.

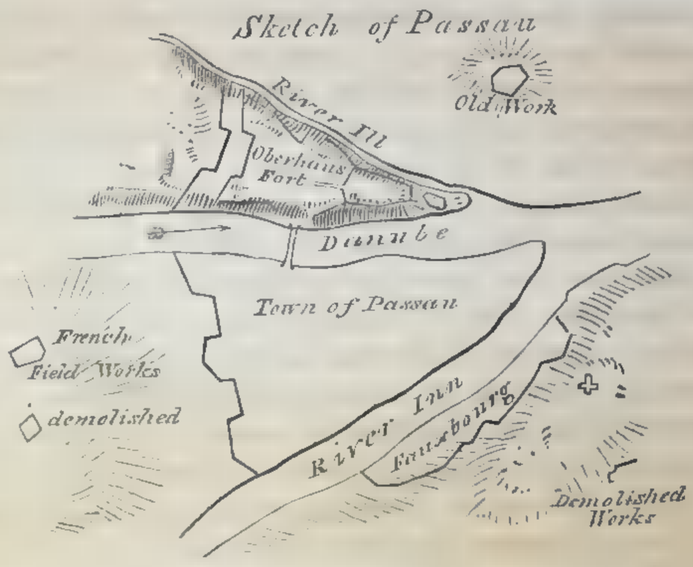
Ingoldstadt, plate 14.—Ingoldstadt contains about 5000 inhabitants. It is intended to give further strength to the town by two detached works of large dimensions, and to fill the ditches by means of sluices in the proposed bridge across the Danube.

These sluices would also form an inundation round the tête-de-pont now in construction; sluices for admitting the water when so raised, between the glacis and the glacis "à contre-pente," being nearly complete. The cavalier casemates shaded dark, are so far advanced, that the greater part of the upper arches were turned in September last (1831). The casemates lightly shaded, are only four feet above the foundation. The enceinte, and the other parts shown in outline, must be considered a mere sketch to convey the general idea.

The masonry already performed is beautifully executed. The revetements are of very hard stone (resembling ■ coarse grey marble), most accurately cut, and ornamented with a cordon and ogee at the base, and by rustic-work arches above the embrasures, which must have caused a great unnecesssary expense. The arches are formed of very hard red bricks of ■ large size, and fine quality, some of which were cast to the pattern required. This permitted the centres to be struck as soon as the arches were keyed. The dos d'anes were not finished, but the drains from them passed through the middle of the piers, which are seven feet thick. These works are planned by General Streider, who superintends their execution. They are different from any now constructed, and the cavaliers appear rather to follow the old tracings of Albert Durer, than the towers of Montalembert. By the circular form of the enceinte, the effects of ricochet firing would be in some degree avoided: it is covered by a small contre-pente glacis, to allow of sorties. The sections A, B, C, show the profile of the cavaliers, the supposed one of the enceinte, the contre-pente, covert-way, and the two glacis; with the presumed height of the inundation. There is however little chance of these works being completed, the legislative assembly having limited the expenditure on them to 7000*l.* of the public money in November last; but the King, who has considerable private means, would probably add to this sum, which would only finish the cavaliers that are almost completed. It is indeed of great importance to Bavaria, that there should be a strong fortification here, as it communicates, by an excellent road of thirty miles in length, with Munich, which would allow the Court to take refuge in cases of necessity, and also to concentrate the army in a defensive war, as it gives the means of acting on either side of the Danube. The surrounding country being exceedingly flat, the place could have been made strong at a small expense, after the construction of the proposed sluices across the Danube, which must be well protected from floating ice in the winter.

Passau.—Passau contains 10,000 inhabitants; it is called the Coblenz of the Danube, and is situated at its confluence with the river Inn (which is nearly equal in size), and the Ill. It is the centre of a considerable water communication.

The Oberhaus fort has a very striking resemblance to the old works at Ehrenbreitstein both in plan and elevation, but is greatly decayed, and has not so good a command over the ridge of which it forms the extremity. There is a considerable casemated accommodation still habitable.

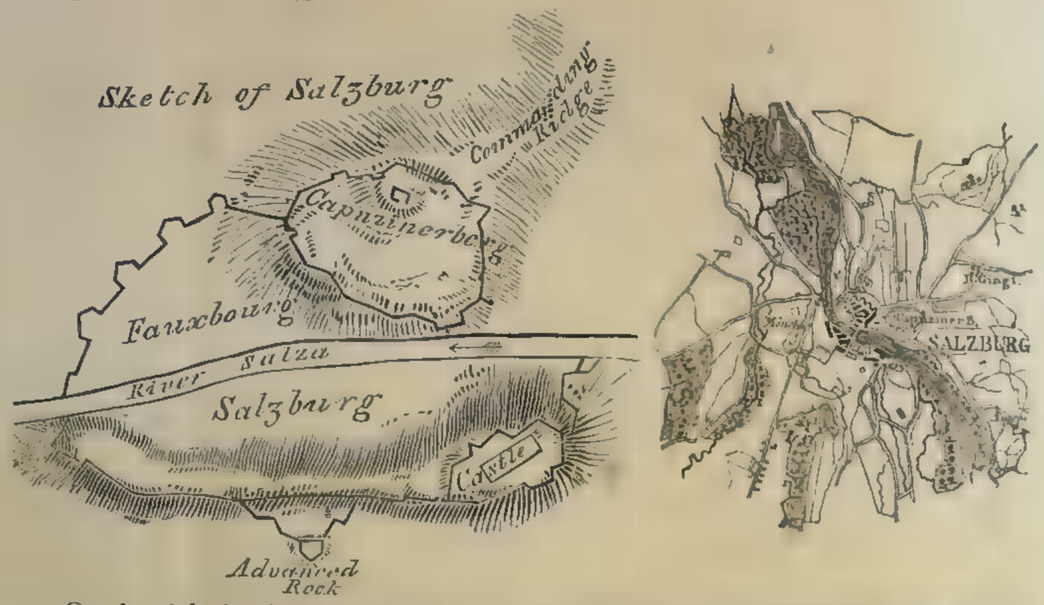


The works enclosing the town and fauxbourg are in ruins. This site was fixed upon by Napoleon (when allied to Bavaria), as most eligible for a grand depôt against Austria; and accordingly considerable earth-works were thrown up on the surrounding eminences, but they are now demolished.

The Austrians having considered it desirable to give further security to the valley of the Danube, which leads immediately to Vienna, between the mountains of the Tyrol and Bohemia, Salzburg and Lintz are fixed upon as the most eligible points for defensive works.

Salzburg is situated on the small river Salza, and contains about 10,000 inhabitants. The castle is about the height of Ehrenbreitstein and is on the summit of the ridge of rock which encompasses the town on the left bank of the Salza. It contains a large casemated accommodation, formerly the palace of the bishop, and is of considerable strength on all sides, from the precipitous nature of the rock, particularly towards the country, which is a level plain. It communicates to the town by a rail-road, and by a circuitous road (for horses and light carts) which passes through three enceintes. There are several batteries on different heights (which command the ridge and town) dependant on the keep of the castle, and having very high escarps: the lowest part of the ridge surrounding the town is 50 or 60 feet high; it is surmounted by a small wall forming the enceinte, and is roughly scarped. In the project for strengthening this side, it is proposed to complete the scarping of the rock, to form it into a

regular rampart; and to connect an insulated rock, which has been already cut into the shape of a ravelin sixty feet high, thus forming a good flank to the base of the ridge, and an extensive place-d'armes in front of the principal entrance, which is cut through the rock. It is also intended to add some low works at each extremity adjoining the Salza, to give a flank to that part, and cover the other two entrances of the town, the fire of the ridge over these works being like that of a high cavalier.



On the right bank of the Salza, the suburb is closed principally by the Capuzinerberg, which externally is broken into rocky precipices. It has a small keep near the summit, about fifty feet higher than the castle on the other side of the river, and an enceinte leading down towards the river (which the rock overhangs) as it enters the town; and on the other is connected to a few regular fronts which join on to the lower part of the river. The country near the town on this side is also nearly level, with the exception of a ridge proceeding from the Capuzinerberg, which obtains an equal height with it at about 1600 yards distance. It is proposed to do little more (on this side) than to improve the old enceinte, although, where the rocks are precipitous, it consists only of a common wall of about twelve feet in height, broken into angles, giving irregular flanks. This is considered sufficient, as the Tyrolese sharp-shooters would be employed in its defence, and there would be then very great difficulties to overcome before guns could be brought near enough to destroy the defences. The site of Salzburg is considered to be too remote from the Danube to support sufficiently

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the troops engaged in opposing an enemy advancing on Vienna; but as it may be easily made defensible, an estimate has been made for the works required, and it is considered probable that they will be ordered when those of Lintz are completed.

Lintz, plate 15.—Lintz contains about 25,000 inhabitants. It is well built, having three squares, and the streets being generally wide and open. An old redoubt in each was the only work of defence previous to the construction of the present towers, one of which was built about three years since; the others, shown on the plan, were commenced in 1830 and 1831.

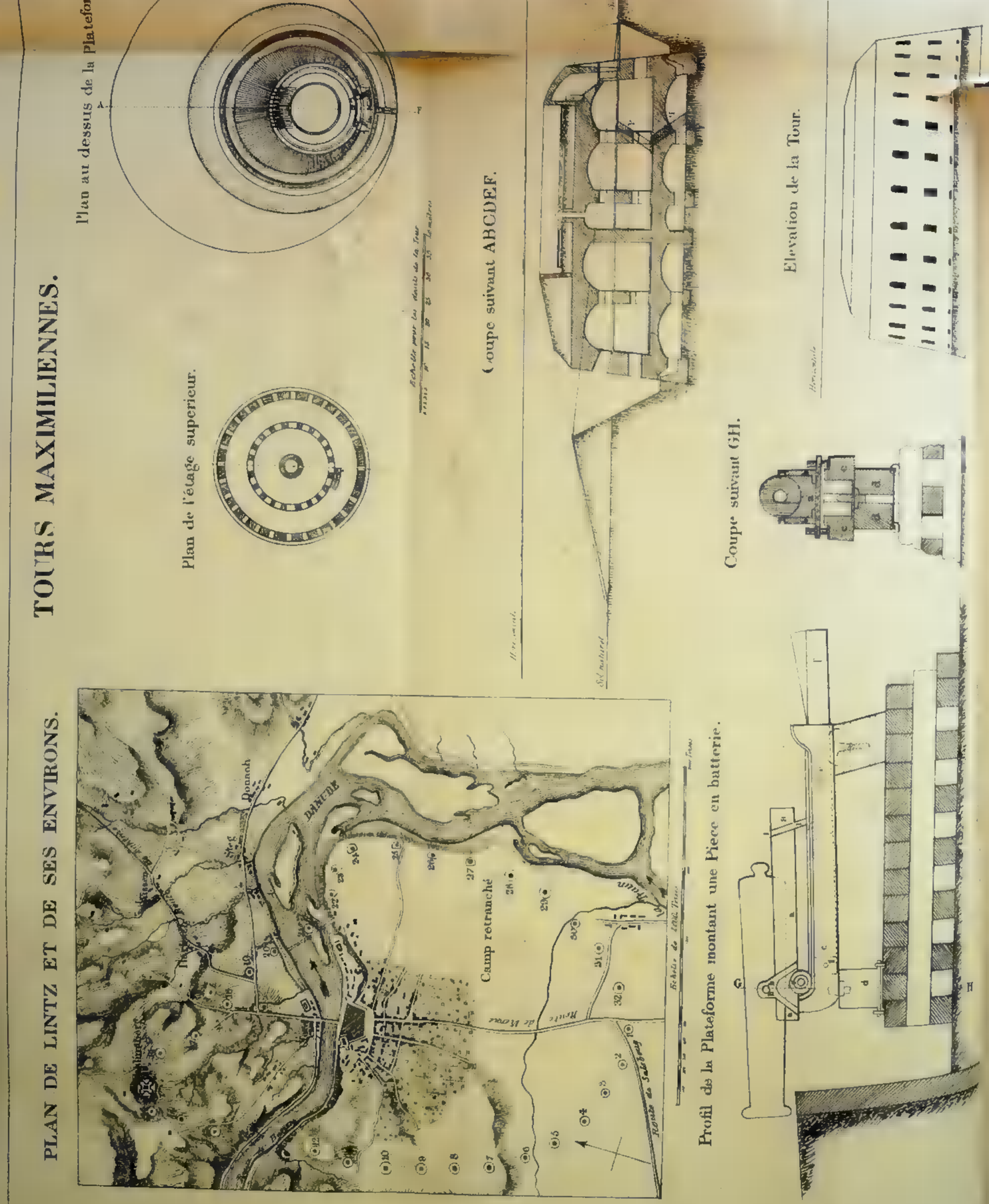
The following account of the works at Lintz is taken from the memoir of Captain Allard, of the French Engineers, in the Spectateur Militaire of April 1835 :—

"The Maximilian tower is circular. Its diameter at the base is 118 feet, and at top 110 feet; its height about 33 feet, and the mean thickness of the scarp 6 feet 6 inches; it is surrounded by a ditch, which is 26 feet wide at the point most exposed, while it diminishes gradually to the gorge of the work, where it is only 13 feet wide, at which point a drawbridge gives access to the gate of the tower. The earth excavated from the ditch is formed into a glacis, raised sufficiently to cover the masonry of the tower in front from the view of the enemy: this glacis diminishes gradually towards the gorge of the work, where it ceases.

"At the centre of the tower is a hollow circular shaft, 10 feet in diameter: the space between the exterior of this cylinder and the interior of the escarp is divided by a set of piers, upon which rest the arches, forming a bomb-proof covering to the interior of the tower.

"The tower has three floors. The lowest is partly below ground, is used as a magazine and place of depôt for stores and ammunition, and has a bomb-proof covering; the second, which is covered by a simple floor, and lighted by windows, serves to lodge the garrison, and contains the kitchens and all the necessary accommodations. The fire-places are placed between the windows; the smoke is conveyed to the exterior by a metal pipe. The upper floor is left open between the piers, becoming thus one large casemate; the escarp is pierced with embrasures, and two howitzers are mounted upon light carriages, which can be moved from one point of the circumference to another, as may be required. These howitzers, when acting towards the exterior, fire à ricochet over the glacis, but they defend all the ground within the line of towers by a direct fire.

"On the upper, or bomb-proof stage of the tower, which is covered with



3 feet of earth, a battery of eleven 24-pounders is mounted; this is called the deck, from its resemblance to the deck of a man-of-war. The battery is protected by a parapet 33 feet thick towards the exterior, and only 10 feet towards the interior, including thus a circular space, whose centre does not coincide with that of the tower. In rear of the parapet is a circular platform, composed of three rows of heavy timber; the upper and lower rows are arranged in the direction of the curve, while the centre tier is in the direction of the radius; two grooves in the front part of this platform serve to receive and guide the trucks of the carriage of the gun, which is a short 24-pounder, and is mounted in a peculiar manner, as will be seen by the following description.

"The gun is sunk into a beam (marked *a* in the drawing), and fastened down to it by a band of iron fixed to the trunnions; a cast-iron hollow axle is fixed to this beam, and on this are two cast-iron trucks, which run in grooves in the beams composing the lower part, or cheeks of the carriage, and allow for the recoil and working of the gun. The front transom of the carriage has a socket, which fits upon a pivot projecting upwards from the lower part of the carriage, which, as before stated, is moveable upon trucks running in the grooves of the platform, and by which the whole carriage is moved to any point in the circumference of the platform. The two cheeks of the carriage rest in rear upon two blocks, which, when the carriage is moved, are either lifted with it, or made to slide on the platform; between the cheeks of the carriage a sill or lever is placed, which is fixed at one end by a bolt (*g*), and is supported at the other by the elevating screw; on the projecting end of this lever is an inclined plane, which in some measure checks the recoil. The gun rests upon the lever by the intervention of a bolt passed through holes in an iron band, the two ends of which embrace the lever: there are several of these holes by which variations may easily be made in the elevation of the piece. The grooves in the cheeks of the carriage are 4 feet 6 inches long; the lower part of the carriage, which runs on the platform, is 1 foot high and 1 foot 6 inches long; the rear transom, which receives the elevating screw, is moveable, which allows of a rapid alteration in the elevation. A similar alteration may be made in the contrary direction, by moving the bolt which bears on the lever.

"The carriages of the howitzers in the upper story are framed on the same principle as those just described. The front part of the carriage is not upon trucks, as the howitzers are not expected to move like the guns of the battery. The rear supports are connected with bolts, in such a manner as to enable the carriage to be raised or lowered easily. The most striking difference between

the carriage of the howitzer and that of the guns, is the position of the trucks upon which the piece recoils, which in the howitzers are fixed to the trunnions; a piece of cast-metal, something like the butt of a musket-stock, is fixed to the piece itself.

"These carriages, as well as the towers themselves, were invented by Prince Maximilian, and form an essential part of the system. They do away with the inconvenience which has been hitherto justly charged to all systems on which towers form the staple defence, viz. that of being unable to concentrate a heavy fire upon any given point. It may be seen by the plan, that in case of necessity, the fire of all the eleven guns may be brought to bear upon one point, as they are easily moved upon the platform, and occupy but a small space.

"The motion of the upper part of the carriage upon the pivot in front allows the gun to be pointed in a direction very oblique to the radius of the tower, without necessitating the removal of the trucks from the grooves in the platform. Between the platform and epaulement, a space of 1 foot 6 inches wide is left for the convenience of the men who load the guns; of these men there are only four for the whole battery. When loading or sponging the guns, they stand upon the edge of the platform: this duty is difficult and dangerous, as the men are exposed above the parapet during its continuance, and it requires steady experienced soldiers to perform it.*

"The six men who work the guns remain in rear of the platform, and raise themselves upon it to perform their duties. The upper story of the tower is on a level with the ground outside, and a communication is made to it by a drawbridge in rear of the work: from the upper story, a double staircase within the scarp-wall leads to the platform, and the outlet is covered by an arch, the crown of which does not rise above the parapet: in cases of necessity, the guns of the battery can be fired over it. The men who load the guns are enabled to make the circuit of the exterior of the platform, between it and the parapet, by descend-

* The artillerymen would be much exposed to an enemy's fire even on a plain; but as several of the towers are situated on ground commanding that in front, it would be there necessary to elevate the carriages much more, in order to give the necessary direction to the fire. Several experiments were therefore making, on an experimental platform, to overcome this fault, which might be much diminished if the gun were to be placed on a common English sea-carriage recoiling on a plane sufficiently inclined for it to return from its own weight, after being kept back by a catch-lever, so that the gun might be retained while it is loaded; additional space and security might also be given to the artillerymen in front by arched recesses under the parapet.

ing the upper flight of stairs, moving along the landing-place, and ascending the opposite flight, both of which open into the space: but it is more difficult to work the guns in this spot than in any other. Two small expense magazines, each containing about 100 cartridges, are disposed on the sides of the staircase: a staircase leads to the lower stories. The central cylinder of the tower is arched over at top, a small opening being left, which is covered with a metal cap, to guarantee it against the weather, or the effect of projectiles. Ammunition and spare carriages are conveyed from the magazines to the platform, either by the staircase, or through this opening, where a system of pulleys enables heavy weights to be moved from below. A communication is made on each floor with the central cylinder, which, in ordinary times, is used for various purposes; a place of confinement for offenders, a magazine, &c. The garrison of each tower amounts to 150 men, of whom 12 are gunners.

"Having thus given the details of the construction of one of the Maximilian towers, it only remains to describe the entrenched camp at Lintz, where they have been applied on an extensive scale. The principal object in establishing this intrenched camp, was to make Lintz a secure refuge for a beaten army; and it was supposed, that the means of attack would be limited to the field-train, which explains the reason why so little care has been taken to cover the scarps of the upper story, which can be seen from the exterior for a large portion of the circumference of the tower, but which from their thickness are supposed to be able to resist the fire of field-pieces.

"The intrenched camp is surrounded by 32 of these towers, which occupy all the high ground surrounding the town, on both banks of the Danube. The radius of this enceinte varies from half a league to a league: its circumference is about four leagues. The towers are placed at unequal distances apart, but in no case does this distance exceed 600 yards: neither are all the towers exactly similar in construction; they are modified to suit the ground: but the foregoing description will serve as a general type of the plan on which they are constructed. The line of towers is not altogether so regular as is represented on the plan, the form of the ground not permitting it. No. 1 tower is on the road from Lintz to Vienna, by Ebersberg. No. 2 and the following numbers ascend the valley of the river, No. 12 being on the right bank and No. 13 on the left; but between these two are situated, on the very edge of the bank, two towers mounted with guns on depressing carriages, which look into the valley of the river. From these two towers, and flanked by them, two loop-holed walls are carried down the bank,

and so far into the bed of the river, as to secure a depth of 8 feet of water at their extremities: these walls, which have a gateway where they are traversed by the main road to Bavaria, and another on the left bank, serve to protect the town from an attack by the valley of the river. The line of towers is continued on the left bank, to a height called Peslinberg, which is important from its position and command. The French intrenched the height in 1809, when they constructed a tête-de-pont in front of the suburb of Ufer; and it is now occupied by a square fort, whose exterior side is 165 yards, and the faces of which are flanked by four towers placed at the angles. From this height, the line of towers descends again to the Danube, which it crosses at the point where a bridge was constructed during the last war. A tower is placed on an island in the river; from thence it follows the bank of the river to the Vienna road, where No. 32 is placed opposite No. 1.

"Nos. 22, 23, 24, 25, 26, and 27, are only half-towers: the want of funds is the reason of this alteration. The Emperor having given Prince Maximilian authority to execute the work, and he having engaged to finish it for a certain sum, the expense of the first tower so far exceeded the estimate, that the Prince determined to construct six half-towers, the saving upon which would compensate for the excess on the others. These half-towers are situated near the Danube, which in some measure protects them: their area is rather greater than the half of the other towers, and they are closed in the rear by a straight wall.*

"In time of war the towers are to be united by a palisaded covered way.

"The following experiment was made some years ago, in order to ascertain the degree of resistance of which these towers were susceptible. A battery was constructed against one of these towers, at the distance of about 300 yards: it was armed with four howitzers, and Congreve rockets, and a fire was kept up upon the tower for about five hours. In a short time, shells having fallen on the roof of the tower, the carriages were broken, the platform injured, and the whole battery on the tower was rendered unserviceable: two Congreve rockets had even penetrated into the upper story. After this first trial, the advocates for the

* The work is, however, cheaply performed, the price of labour being low; the bricks for the arches, doors, and embrasures, and the rough stone for the escarp, being obtained on the spot: one roof for two towers allows (by working at them alternately) the men to work under cover, and the water, where necessary, is conveyed by wooden troughs, from pumps placed at convenient situations.

towers required to be allowed to repair the damage, and remount the guns; and in the following night they made all the necessary repairs in the platform and parapet, and changed the broken carriages, and were ready the next day to open a fire on the battery, which was kept up for five hours, and did great injury to it. The result of this experiment, however, is altogether in favour of the attack, for it proves how very soon the defenders of the towers might be disorganized, and their means destroyed: for although the repairs were quickly made, yet it would not at all follow, that in war the same supply of fresh carriages, men, and materials, would be disposable; and as this damage was produced by one battery, what would have been the effect of two or three? As this tower was soon placed hors-de-combat, should an attack have been made at that time on the place, it could have contributed little or nothing to the defence. This experiment is more conclusive against the principle of the Maximilian towers than any reasoning could be. The invention, after all, turns less on the construction of the towers, which is by no means novel, than on the carriages, and mode of working the guns in the upper battery. The carriage may be looked on as a machine more or less ingenious in its construction; but this is by no means a desideratum in war: solidity, simplicity, and the facility with which changes or repairs may be made, are the first things to be considered; for it must not be forgotten, that a single cannon shot puts an end to the most ingenious and best constructed machine: in like manner, the first shell that falls in the battery will ruin the platform, and the grooves in which the carriages run, and will very probably set fire to the great mass of wood collected together. In the narrow space in which 11 guns are crowded together, it would be difficult, if not impossible, to change a damaged carriage: another inconvenience is the necessity of having such skilful and well-drilled men to work the guns; and as their duty is difficult and dangerous, should they be placed hors-de-combat, the defence of the tower, and its action upon the attack, would suffer very much."

The Austrians have also the fortresses of Leopoldstadt, Theresienstadt, and Josephstadt: they were built after the wars of Frederick the Great, to defend the passes from Silesia to Vienna. In one of these forts, the breach either in the bastion or ravelin may be cut off.—*Plate* 16, *fig.* 5.

The Prussian Rhenish provinces being detached from West Prussia, Erfurt has received additional works to secure it as an entrepôt in front of the line of the Elbe, on which are the fortresses of Magdeburg, Wittenburg, and Torgau.

Plate 16.—Erfurt contains about 20,000 inhabitants. It is situated half-way between the Rhine and Berlin, commanding the main road, which also leads to Leipsic and Dresden.

The town is commanded by two hills; the larger, called the Petersberg, being well fortified, and connected with the enceinte, forms a strong citadel: considerable works have been lately constructed. A casemated barrack, forming a keep, and having guns, which bear on the side of the country, as being most exposed to attack; considerable additions are also making to the former exterior works, and the whole will form a very commanding place of great strength.

Plate 16.—The small hill, called the Cyriacsberg, is occupied by an old work, which has been strengthened, and further additions may possibly be made to it. It affords great facilities for sorties on this side, as troops may be drawn up at any time behind the fort, and the reverse of the hill being steep, the communication with the town is secure. These works protect the western side of the town, and the other points are greatly strengthened by the sluices on the river Gera, which passes it; the country being so flat as to allow of its being inundated; and the whole force of the river may be turned through the ditches. Strict measures are taken to prevent the new works from being seen.

Magdeburg.—Magdeburg contains, with the military and the suburbs, about 30,000 inhabitants, and is the principal military depôt of Prussia. It has never been attacked regularly, but was taken by the Austrians under Tilly, in 1631 (principally by escalade along the banks of the river, since which time it has been greatly strengthened), and by the French, after the battle of Jena, by bombardment and famine. It commands the great northern road from the Rhine and Hanover to Berlin.

Wittenburg.—Wittenburg contains 6000 inhabitants. It is a long narrow town, having one side protected by the Elbe, over which there is a good bridge covered by a tête-de-pont. There is a castle in the town, which has a command over the country on the west side, and serves as a keep, and casemates for the garrison. The ditch is wet, with a low revetement. The enceinte has six fronts towards the country.

Two or three small redoubts, thrown up by the French to protect the entrances, still remain: they have wooden blockhouses in the interior, which are in good preservation.

Torgau.—Torgau was fortified by the orders of Napoleon. General Von

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Aster, now at Coblenz, laid out the works. It contains 5000 inhabitants, and is situated on the left bank of the Elbe, which with seven fronts forms the enceinte. On the opposite side of the river is a large tête-de-pont in earth, with wet ditches. The enceinte of the town contains a considerable vacant space. The works have a good profile, the ditches are wet; the fronts about the usual length; the flanks have six guns, and the same number in casemates. The town is slightly commanded at a distance of about 1200 yards, which site is occupied by old works.

Kœnigstein.—In the kingdom of Saxony, the only fortress now kept up is Kœnigstein, fifteen miles from Dresden. In the wars with Frederick the Great it served as a refuge to the Court, and the crown treasures are deposited there in times of danger. It is a rock, having a natural escarp of from 100 to 300 feet in height, with a flat surface of about twelve acres, situate at the summit of a high hill commanding the Elbe. The enceinte is a wall about two feet thick, which allows of the foot being seen from small projections, and of its defence by stones, shells, &c. The entrance is protected by a low hornwork, and ascends to the terre-pleine of the rock by an inclined plane cut through. The casemates would contain about 1000 men with stores: they also cover a deep well, which has a constant supply of water. The guns are mounted on depressing carriages, which allow of their being pointed at fifty degrees below the line of the horizon, and of their being very quickly exercised. They command the Elbe, and the surrounding country, which is nearly flat; but there is a rock called the Lilliensteín, about 1600 yards distant, that is about thirty feet higher, from which the fort might be annoyed, as also from a rock about two-thirds of the height, at about the same distance.

The Lilienstein is on the opposite side of the Elbe, but is so steep, and the top so small, that there would be considerable difficulty in forming heavy batteries there.

Details of Prussian Works in construction.—The Prussian engineers prefer obtaining casemated flanks to their ditches by caponières, as being more secure than those of bastions. An example of their construction is given in Fort Alexander at Coblenz; but in extensive works now in progress, a more simple and less expensive tracing has been adopted.

Plate 16.—The rampart, as shown in *fig.* 1, may be formed in some cases by a casemated barrack of two stories in height, communicating under

the ditch with the bastions in front; which have a good cross-fire on the glacis, the salient angles being only 200 yards from the collateral flanks. The bastions at the angles of the polygon cover the front from enfilade, and make it necessary for the batteries which oppose the fire of the flank to be placed in them, and they have then to contend with a double tier of guns across the whole width of the ditch.

It may be considered objectionable, that the small ditches of the faces are not seen from the body of the place, and also that in a work of this size they should depend for a flank on their small caponières; but it is probable that these bastions would be countermined in the course of their construction, and also that this tracing arose from the ground falling too much in front of the main ditch, to allow of ravelins being constructed, as in the other parts, as given in *plate* 17, *fig*. 1.

The ravelins covering the caponières in *plate* 17 are considered to be an improvement on the advanced ravelins of Chasseloup and Bousmard, as they may be made nearly as salient on the glacis, and also prevent the body of the place being breached from the counterscarp of their salient angles; while they form a more efficient flank to their ditches, are more under the fire of the enceinte, contain a larger interior space, and there is a great saving of masonry at the gorge, as also of troops to secure it from assault.

In the attack of these fronts, the approaches are opposed, on the capital of the ravelin, by three mortars, under the parapet, cutting off the salient angle of the first part, and by guns behind it. The glacis on each side is protected by the fire of ninety yards of the enceinte, and by eighty yards of the second part of the ravelin, which (being covered by the first part) it is very difficult to enfilade.

The establishment of batteries on the counterscarp of the salient angle is also rendered exceedingly difficult by countermines, and by a double tier of fire the whole width of the ditch, from the enceinte, and from the caponière, which also, after their establishment, would prevent their making a serious breach in the body of the place. The attempts of the enemy to lodge himself on the first part of the ravelin are opposed by countermines prepared in the work during its construction, and by the intrenchment covering the second part, which allows of sorties; also the formation of batteries in the narrow part of the angle, sufficient to silence the defence of the second part, would be opposed by the

fire of the whole of the enceinte behind the ravelin, by that of the casemated keep, and by sorties having their flanks fully protected, which could be only opposed by a very insignificant force. The permanent possession of the second part of the ravelin can therefore only be obtained after the destruction of the keep (which commands every part of the interior, and is not seen from the exterior;) and this is absolutely necessary for the enemy, before he could make his approaches on the glacis to the enceinte for his breaching batteries on its counterscarp, as they would be either taken in flank or reverse. The caponière flanking the ditch of the enceinte is independent of the keep, (which after being taken, would have its gorge open to the fire of the parapet of the enceinte, and of its detached escarp,) and its flanks, having a double tier of fire the whole width of the ditch, can only be opposed by batteries directly in front and of little more than the same width. The establishment of these batteries, and of others for breaching the escarp at one salient angle, would of course require the previous capture of two ravelins; between which the approaches would be sheltered from the collateral works, but they would be diminished in extent on advancing near the place, and consequently expose the troops (concentrated in larger numbers) to a more destructive vertical fire.

From the great projection of the ravelin, and the obtuseness of the angles of the enceinte, the effect of ricochet on the latter is prevented in an octagon, the prolongation of the side of the polygon being intercepted by the ravelin; which might even be made to project further, so as to cover the ditch from enfilade by distant batteries, which would secure the flank from annoyance. The fire of musketry from the detached wall, and from the gorge of the ravelin, protects completely the angle of the flank of the caponière from any assault during the passage of the ditch, so that the flank might preserve its fire to the last.

The salient angle of the enceinte may also be intrenched by a detached wall, as shown to the left of the figure, which would give a great extent of fire on the breach, and would be well flanked by casemates in the rampart of the middle part, or by the casemated barracks, which might be advantageously placed for that purpose.

The following is a comparative view of the above system, as applied to a hexagon, with that approved by the French engineers, and those invented by Bousmard and Chasseloup.

Details.	Prussians.	French.	Bousmard.	Chasseloup.
Interior space within the ramparts, square metres ..	345,600	141,600	130,200	201,600
Length of front in metres	420	360	360	410
Lines of defence in do.	200	260	275	280
Length of upper flank	—	39	48	40
Do. of lower flank.....	—	—	22	14
Opening of the angle of rampart	120	82	110	84
Width of ditch at salient	30	26	16	24
Projection of ravelin beyond the salient of the enceinte in metres.....	180	135	228	195
Flank to ravelin from the enceinte.....	90	80	30	70
Width of ditch to ravelin	24	20	14	20
Do. do. to redoubt	5	10	15	10
Work required.				
Main ditch one front } Excavation, yards superficial	13,100	16,700	13,250	19,700
Ravelin do. do. } Excavation, yards superficial	10,700	9,260	8,900	6,480
Escarp of enceinte one front ..... metres	450	492	640	612
Do. of ravelin do. ..... do.	510	460	560	340
Counterscarp of enceinte, 1 front	420	376	540	550
Do. of ravelin	520	600	620	480
Subterraneous communications to the works	120	190	330	350
Do. do. round the counterscarp, &c...	580	690	1080	1100
Number of fronts required for the salient of the ravelin to defilade the enceinte from the first ricochet batteries	8	40	8	11

Observations on the above Details.

The interior space of each system is calculated to the foot of the rampart of the curtain, continued across the half gorges of the bastion. The upper flanks, except in the Prussian system, are exposed to shells, but those, as well as the lower flanks of all, are casemated. Besides the flank to the ravelin from the enceinte, as stated, the Prussian system gives an additional fire in the ditch of four guns, while the French enceinte may be breached by batteries on the salient of the ravelin, and the ditches of the others proposed are too remote to be well flanked.

In the lengths of escarps as stated, a deduction of one third is made for the redoubt and tenaille of the French, and for the curtains of the other tenailles, to allow for the difference of profile.

The communications round the counterscarp are much more necessary in Bousmard's and Chasseloup's systems, than in the others, in which they are only used for countermines; and a much cheaper plan is shown on the salient of the ravelin, in the plate, which would not be above one-fifth of the expense.

The above statement refers to Chasseloup's small system, which, from its dimensions, could be most easily compared with the others; in the large, having fronts of 590 metres, the enceinte is better protected from ricochet fire than that of Bousmard, and the flanks are obtained from caponières; but the great length of this front would prevent the use of it being very generally adopted.

It appears from the details given of the Prussian system, that great means of resistance are obtained at a comparatively small expense, which means might be increased, when required, by cavaliers, by interior intrenchments, and by a covered-way with redoubts. The armament required would also be comparatively small, as in the flanks, which completely enfilade the main ditches at a short range, a few pieces only would be necessary, to prevent a coup-de-main, while a full supply to resist a serious attack might be brought, by easy and secure communications. A few guns, placed on the salients of the ravelins, would be sufficient to keep off an enemy until he had broken ground, when the whole disposable guns of the place might easily be brought upon the enceinte on that side, and the second part of the collateral ravelins. The fatigue attending the usual arrangements would be also greatly diminished by this easiness of access throughout: the garrison therefore need not be numerous, as they are not required to expose themselves in outworks beyond the main ditch; they are protected by casemates in the flank defences (which are sufficiently strong to allow of their concentrating nearly the whole force on the points of importance), and being generally moveable and concealed from the enemy, do not give known or fixed points to his vertical fire.

IX.—*On Contoured Plans and Defilade. By Lieutenant* Harness, *Royal Engineers.*

Although horizontal contours have been, for some time, very generally used by our officers in the representation of ground, the operations that can be performed on an accurately contoured plan were almost entirely unknown to us, until Captain Macauley, about three or four years ago, published some problems connected with the subject, in the Appendix to his work on Field Fortification.

The practice of designing works, by the use of such plans alone, has however been long common in France; instruction in this art forming one branch of the course at the school of application for her engineers at Metz. It would be presumption, therefore, to endeavour to give a new arrangement to the subject; and the only object of this paper being to make the methods invented and employed by the French more generally known, it is principally taken from a Memoir, by Captain F. Noizet, to be found in the sixth number of the "Memorial du Génie."

To describe an object by contours, is to trace on its plan, in their proper relative positions, a number of horizontal sections of such object, and these are generally taken at equal vertical intervals. In the drawings prepared for forming the design of a fortification, the ground is thus represented, the level of each contour, or of any particular isolated points, being given in figures, above or below some assumed plane of comparison; and, since the horizontal and vertical position of every point can then be at once discovered, ordinary sections are unnecessary. In the progress of the design, it becomes necessary to consider the different planes of fire, and planes of defilade; to represent each of these planes by contours also would create confusion; a line, for each plane to be considered, is therefore drawn in any convenient part of the paper, and generally in the direction of the slope of the plane: this line, being graduated, or marked at the points where the contours would intersect it, forms what is called the scale of the plane.

A right comprehension of these scales of slope, is the most essential point towards acquiring the power of using contoured plans; and taking it for granted, therefore, that there is no difficulty in understanding that, in designing a work, it

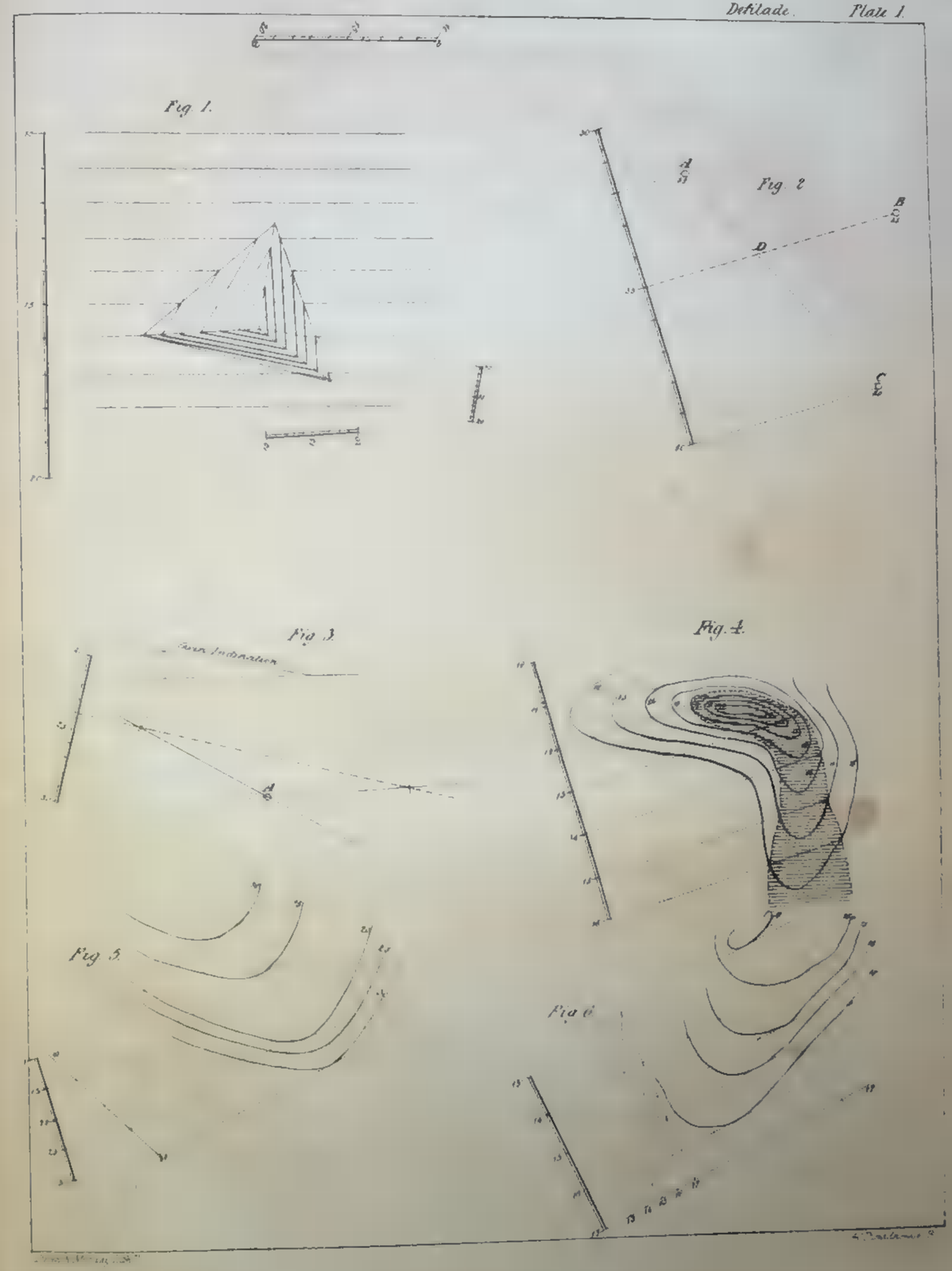
is necessary to consider the different planes mentioned, a more minute description of the method employed for defining them shall be given.

In order to describe exactly the position of a plane, three elements should be given, viz.: the direction of its slope, its inclination to the horizon, and the level of some point on its surface. In expressing a plane by horizontal contours, which are evidently perpendicular to the line of greatest slope, the direction of the slope is indicated. If the contours be drawn at regular vertical intervals, and the same vertical unit be employed throughout the drawing, they will be nearer together in the steep than in the gentle slopes, their distance asunder being in fact the base due, with the slope represented, to the given vertical unit: thus, if that unit, or the difference of level between the contours, were 2 feet, and the slope 1 in 5, the distance between them in plan would be 10 feet; if the slope were 1 in 20, their horizontal distance asunder would be 40 feet: the degree of slope is therefore indicated. Lastly, the position of the plane in space is determined by giving, in figures, the level of one or more of the contours. Now the scale of a plane gives all the above elements without covering the paper with lines: the divisions on that scale, agreeing with the horizontal intervals between the contours, express, exactly as they would do, the inclination of the plane; the direction of the slope is shown, almost invariably, by that of the scale, or, if this be drawn obliquely to the slope, by the direction given to the graduating lines, which are in fact small portions of the contours of the plane; and the position of the plane is finally given by putting the numbers, corresponding to those contours of which the graduating lines are portions, to the scale.

In illustration of the above, *fig.* 1 represents by contours, at vertical intervals of $\frac{1}{16}$ of an inch, a triangular pyramid standing on a plane inclined at 15°; its sides, in the supposed position, having inclinations of 30°, 45°, and 60°: the scales of the several planes comprised in the figure are also given, and *a b* is an oblique scale of the plane to which it applies.

The geometrical constructions that can be performed on contoured plans are numerous; the general principle of scales of slope being, however, once rendered familiar to the mind, these are so easy as hardly to deserve to be divided into problems; and it will be sufficient, before passing to their application, to mention a few of them only.

1. The inclination and direction of the slope of a plane passing through three given points A, B, C, *fig.* 2, which are not in the same straight line, may be found by so dividing the line A C, joining the highest and lowest of the given points,



that the two parts may bear the same proportion to each other, as the numbers expressing the difference of level between the third, or intermediate point, and each of the other two: that is, making A D : D C :: A~B : B~C; the point of division D will then have the same level as B, and the line B D will be a horizontal of the plane required; lines parallel to it, drawn through A and C, will give two more horizontals of the plane; by dividing the spaces between these into as many parts as their differences of level may render necessary, and by continuing to trace them at the intervals thus ascertained, any number can be given; or by drawing a line in any convenient part of the paper, intersecting a few of these horizontals, and retaining just so much of each as may be sufficient to mark their direction as well as the points of intersection, adding their respective levels, a scale is substituted for these lines, and data preserved for employing the plane in succeeding operations.

If three points are in the same straight line, an infinite number of planes may be made to pass through them; but if their projections in plan are in one line, and the points themselves are not, only a vertical plane will do so.

2. If it be required to find the scale of a plane, which shall pass through two given points and have a given inclination, the inclination at once determines the interval, in plan, between two contours of which the difference of level is given; it therefore determines the interval, in plan, between the contours passing through the two given points; and the problem is completed by drawing, through the given points, two lines parallel to each other, and having that interval between them: having thus obtained two contours of the plane, the scale is readily made. If the distance between the points be less than the necessary interval between the contours passing through them, with the given inclination for the plane, the problem is impossible; and, when possible, it always admits of two solutions: for if, in order to draw the contour lines at the required distance asunder, an arc be described, with one of the given points as a centre and that distance as a radius, two tangents can be drawn to such arc from the other point, one on either side of that employed as the centre.

3. The scale of a plane which, passing through a given point, is parallel to a given plane, is easily found; for, in direction and in the length of its divisions, it would be the same as that of the given plane, differing only in the numbers applied to those divisions, which must be altered to correspond with the level of the given point.

4. If it be required to find in a plane, given by its scale of slope, as in *fig.* 3,

a straight line, which passing through a given point in that plane shall have a given inclination, but less than that of the plane; trace a contour of the plane, having any convenient difference of level above or below the given point; and then, with that point as a centre, and with the base due, with the required inclination of the line, to the assumed difference of level as a radius, describe an arc cutting that contour; the line, drawn through their intersection and the given point, will evidently have the required inclination. This also admits of two solutions, since the arc will cut the contour line in two places.

The difference of level between the point and the assumed contour is shown by the scale of slope, and being taken off from the scale of the drawing, is applied to the given angle of inclination. In order not to have to judge the value of small quantities on these scales, a point may be assumed on one of the contours, and a line having the required inclination be drawn through it; another, parallel to this, and passing through the given point, will be that sought. The vertical unit, or distance between the contours, in *fig.* 3, is $\frac{1}{16}$ of an inch.

By the above, a road up the side of a hill, represented by contours, could be so traced as not to exceed in any part a given inclination.

5. The intersection of two planes is found by producing, until they meet, two or more contours, having corresponding levels of each; the line joining the points of meeting must be that of their intersection; or if one of the planes be horizontal, their intersection will be that contour of the inclined plane which has the level of the horizontal one; or if the contours of the planes be parallel, the direction of their slopes being the same, their intersection, being a horizontal of each plane, will be known if one point in it be found; such point may be determined by making a vertical section through the planes; or by assuming a third plane, and marking its intersection with each of the others, the meeting of these two lines of intersection being the point required. Assuming a third plane is of course merely drawing two lines parallel to each other, in such direction, with such interval, and such levels assigned to them as may be convenient. When the contours are nearly parallel, two such planes can be employed to find the intersection, one point in the line required being obtained by each.

6. By the use of an auxiliary plane, as above, the intersection of a line with a plane is easily found: in this case the plane is assumed passing through the given line, and the line of intersection of the two planes cuts the given line in the point required.

7. Through two given lines, two planes may be described parallel to each other; for, through a point in one of them, a line being drawn parallel to the other, the plane which passes through the lines that meet will be one of the two required; and a plane described parallel to this, passing through the other line, will complete the operation. If the two lines are parallel, there are evidently an infinite number of such planes; and if the lines intersect each other, or would do so if produced, the solution is impossible.

8. It may be required to draw, through a given point, a perpendicular to a given plane: now it is sufficiently obvious that the direction of such perpendicular must be at right-angles to the contours of the given plane, and also that its inclination to the horizon must be the complement to that of the plane; the base, due to a given rise on the one, will be equal therefore to the rise due to a given base on the other; and on this principle the line, after being drawn in the required direction, may have its levels determined; for if a second point be taken, by setting off upon it, from the given point, any convenient number of the vertical units employed, the horizontal distance due to the assumed number of vertical units on the given plane will be the difference of level between these two points.

9. A plane may be described perpendicular to a given line; the given line being considered the scale of a plane, another line is drawn perpendicular to it, as above; the latter will be the scale of the plane required.

10. A line may be drawn, through a given point, perpendicular to a given line, by describing, through the former, a plane perpendicular to the latter; the line joining the given point, and the intersection of the line and plane, will be the perpendicular required.

11. The angle made by two right lines may be measured by drawing, through any point in one of the lines, a perpendicular to the other; this will be the tangent of the angle, the distance between the foot of the perpendicular and the angular point being considered radius.

12. In like manner, if it be required to measure the angle at which a right line is inclined to a plane; a perpendicular to the plane, from any point in the line will be, as before, the tangent of the given angle.

13. The angle made by two planes may be measured by drawing in each plane a line perpendicular to their common intersection at the same point, and finding the angle made by those lines.

Constructions similar to the preceding, may be performed when the waving contours expressing the ground about the site of a work are a part of the elements employed. The surfaces they represent being considered to be made up of

a straight line, which passing through a given point in that plane shall have a given inclination, but less than that of the plane; trace a contour of the plane, having any convenient difference of level above or below the given point; and then, with that point as a centre, and with the base due, with the required inclination of the line, to the assumed difference of level as a radius, describe an arc cutting that contour; the line, drawn through their intersection and the given point, will evidently have the required inclination. This also admits of two solutions, since the arc will cut the contour line in two places.

The difference of level between the point and the assumed contour is shown by the scale of slope, and being taken off from the scale of the drawing, is applied to the given angle of inclination. In order not to have to judge the value of small quantities on these scales, a point may be assumed on one of the contours, and a line having the required inclination be drawn through it; another, parallel to this, and passing through the given point, will be that sought. The vertical unit, or distance between the contours, in *fig.* 3, is $\frac{1}{16}$ of an inch.

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11. The angle made by two right lines may be measured by drawing, through any point in one of the lines, a perpendicular to the other; this will be the tangent of the angle, the distance between the foot of the perpendicular and the angular point being considered radius.

12. In like manner, if it be required to measure the angle at which a right line is inclined to a plane; a perpendicular to the plane, from any point in the line will be, as before, the tangent of the given angle.

13. The angle made by two planes may be measured by drawing in each plane a line perpendicular to their common intersection at the same point, and finding the angle made by those lines.

Constructions similar to the preceding, may be performed when the waving contours expressing the ground about the site of a work are a part of the elements employed. The surfaces they represent being considered to be made up of

many planes, it may appear unnecessary to repeat them; but there are some too important to be left to the ingenuity of the officer who may wish to apply them.

14. The intersections of the horizontals of any plane, with the contours of a given surface, at corresponding levels, show, as in *fig.* 4, what part of such surface rises above that plane. By performing this operation with the planes of defilade of existing works, it is discovered from what places such works may be seen into: by it also may be determined the meeting of a glacis, or other artificial slope, with the natural ground.

15. But the problem principally required in perfecting the designs for works of defence upon irregular sites, is that by which their planes of defilade, or their imaginary planes of site, are determined. The conditions to be fulfilled in these cases are, generally, that the plane shall pass through a given point or line, and be either a tangent to a given surface, or pass at a certain height above it, which is the same thing, since it is only necessary to consider the surface raised by that quantity, increasing the given level of each contour by the required number of feet.

If then it be required to find the plane which, passing through a given line, shall be tangential to a given surface, it is only necessary, when the line is inclined, to mark, (producing it, if necessary,) the points having the same level as the contours of the given surface, as in *fig.* 5; and then to draw, from each of these points, a tangent to the contours on the same level with it; the tangent which makes the smallest angle with the lower part of the given line will be a horizontal of the plane. For it is sufficiently evident, that the planes, of which the lines thus drawn are the respective horizontals, would meet the surface at the points where these horizontals touch its contours, and that when the position of the given line and arrangement of the given surface are such that the required plane must rise from the given line, the steepest of these planes will leave the given surface below it everywhere, except at the point of contact; and that plane, of which the horizontals make the smallest angle with the given line, must be the steepest, for their distance asunder is then smallest: but when the disposition of the line and surface is such that the required plane must descend from the given line, it will be that of least inclination, and then the line which makes the greatest acute angle will be a horizontal of the plane required.

Now in the first case the tangent will make an acute angle with the lower, and in the second case with the upper part of the given line; it follows therefore

that the tangent which makes the smallest angle with the lower part, as above stated, is always the horizontal sought.

Or, if the given line be horizontal, a tangent parallel to it should be drawn to each contour of the given surface; and then, by making a vertical section through these tangents and the given line, it will be seen through which the required plane must pass in order to leave below it all the others. This, however, may be ascertained without making a vertical section; for, as before, it is evident that it must, according to the arrangement of the levels of the line and surface, be either the most, or the least inclined of the several planes, passing through the given line and one of the tangents to the contours, that will leave the surface entirely below it; and that in the first case the tangent whose height above the given line is greatest, in proportion to its distance from it, must be a horizontal of that plane; while in the second case, when the given line is higher than those parts of the surface at which the contact is likely to take place, the plane of least inclination will fulfil the condition required, and the tangent whose difference of level below the given line is least, in comparison to its distance from it, will be a horizontal of that plane. A method for ascertaining which tangent should be adopted, without a vertical section, was first proposed by Captain Noizet, in the paper already referred to. He traces through any point in the given line, as in *fig.* 6, a line cutting the tangents drawn to the contours of the surface; he then sets off upon the given line, beginning from the same point, distances proportional to the several differences of level between the given line and each contour; which operation, when a constant vertical interval has been preserved between the contours, is merely setting of a number of equal parts along the line: to these points of division he applies the numbers of the several contours, beginning from the point first assumed, which retains the level of the given line, and joins each with the point where the line drawn cutting the several tangents, intersects that having the corresponding level. Then, similarly to the former case, the line making the smallest angle with the given horizontal, on the side where the numbers denoting the lowest levels are affixed, meets the tangent through which the required plane must pass.

If the plane be required to pass through a given point and to touch a given surface, it is obvious that there will always be several planes which may fulfil these conditions; in practice, however, it would generally be desirable to adopt, for a plane of site, or defilade, that which has the least inclination. To find this plane, draw through the given point, as in *fig.* 7, several lines cutting the contours

of the given surface, and graduate them in such manner that they may be tangential to that surface; this may be done by making a vertical section on each line, and then determining its proper inclination; or by a method similar to that described above, for finding which tangent was the horizontal of a plane required to pass through a given line and touch a given surface. A line being assumed in the present case, on which to set off the divisions, each line to be graduated may represent in turn the secant to the several contours and tangents, and the points of intersection with the former, be joined to those of division on the assumed line, having corresponding levels: the line of junction making the least angle with the descending side of the assumed line will determine the point of contact with the surface, and consequently the level of a second point upon the line to be graduated.

The several lines having been so chosen that any plane passing through two, adjacent to each other, would not cut the intervening surface, having been in fact drawn in those situations where the contours, curving towards it, approach nearest to the given point, and being graduated by one of the foregoing methods, it only remains to find the plane of least inclination, which passing through one or more of these lines shall leave the others below it. For this purpose, join the points having any assumed level on each line, to those of corresponding level on the adjacent lines, and form in fact a horizontal section of the solid angle defined by them; of the tangents that can be drawn to that section, leaving every part of the latter on the opposite side to the given point, that which makes with the graduated line passing through the point of contact, an angle most nearly approaching to a right angle, will be a horizontal of the plane required.

By the foregoing processes, or others so closely resembling them as to be easily discovered when the mind has become familiar with the subject, the trace and relief of works may be arranged for the most complicated sites, from the data afforded by contoured plans alone. The engineer would not however confine himself to the use of constructions adapted only to a horizontal projection, but employ vertical sections, or for obtaining dimensions accurately, calculations, as his judgment might think fit.

It of course is not intended in this paper to discuss the principles which should be observed in occupying a given site. The first idea of such a project must be varied according to the object to be fulfilled, and it would vary yet more with the genius of its author.

The general arrangement of the trace however being decided, that of the

reliefs may be completed almost by rule, so as to fulfil the different conditions required in the design of a fortress, viz.: that it shall defend the ground within reach of its arms; that every part of the ditches shall be defended; that all the works in advance shall be defended by those in rear; and that the whole shall be properly defiladed.

The steepest planes of the ground intended to be seen by any particular part of the work, being produced to their intersection with the vertical planes passing through its interior crest, at once point out the smallest command by which the first condition can be fulfilled; the two next require no comment, an ordinary section will at once determine the greatest admissible difference of level between the nearest point of a ditch or terre-plein to be defended, and the crest of the work defending it. The methods by which the last condition is complied with shall be more fully described.

Of Defilade.—When irregular ground has to be occupied, an imaginary plane of site is sometimes employed to facilitate the operations required in arranging the defilade; this plane is generally tangential to the most commanding points, leaving below it all the ground about a work, and at the same time reducing to an even surface the intended site, either of the whole work, or of the part under consideration, or so cutting it as to equalise the remblai and deblai required for the construction. The plane of defilade is that which, passing through the covering line of a work, leaves at a sufficient distance below it all the neighbouring ground. When these two planes are parallel, the different parts of a fortification may be said to have the same relation to each other and the surrounding country, as if constructed according to the usual supposition in elementary descriptions upon horizontal ground.

When the slopes about the site are very gentle, the points of command few, and but slightly raised above the intended work, an inclined plane as above may be adopted for the plane of site, and the reliefs and depths of ditches, which would have been suitable on a horizontal site, assigned to the different parts above and below it. But, when the slopes are steep, or the points of command elevated, it will become impossible to keep the two planes parallel, and the height at which the plane of defilade passes above the ground, must be less than the command of the work above the plane of site, in order to keep the relief within reasonable limits, and prevent inconvenient inclination in the terre-pleins; these considerations rendering it sometimes necessary to adopt in the same work, and even in the same face of a work, different planes of defilade. In this case,

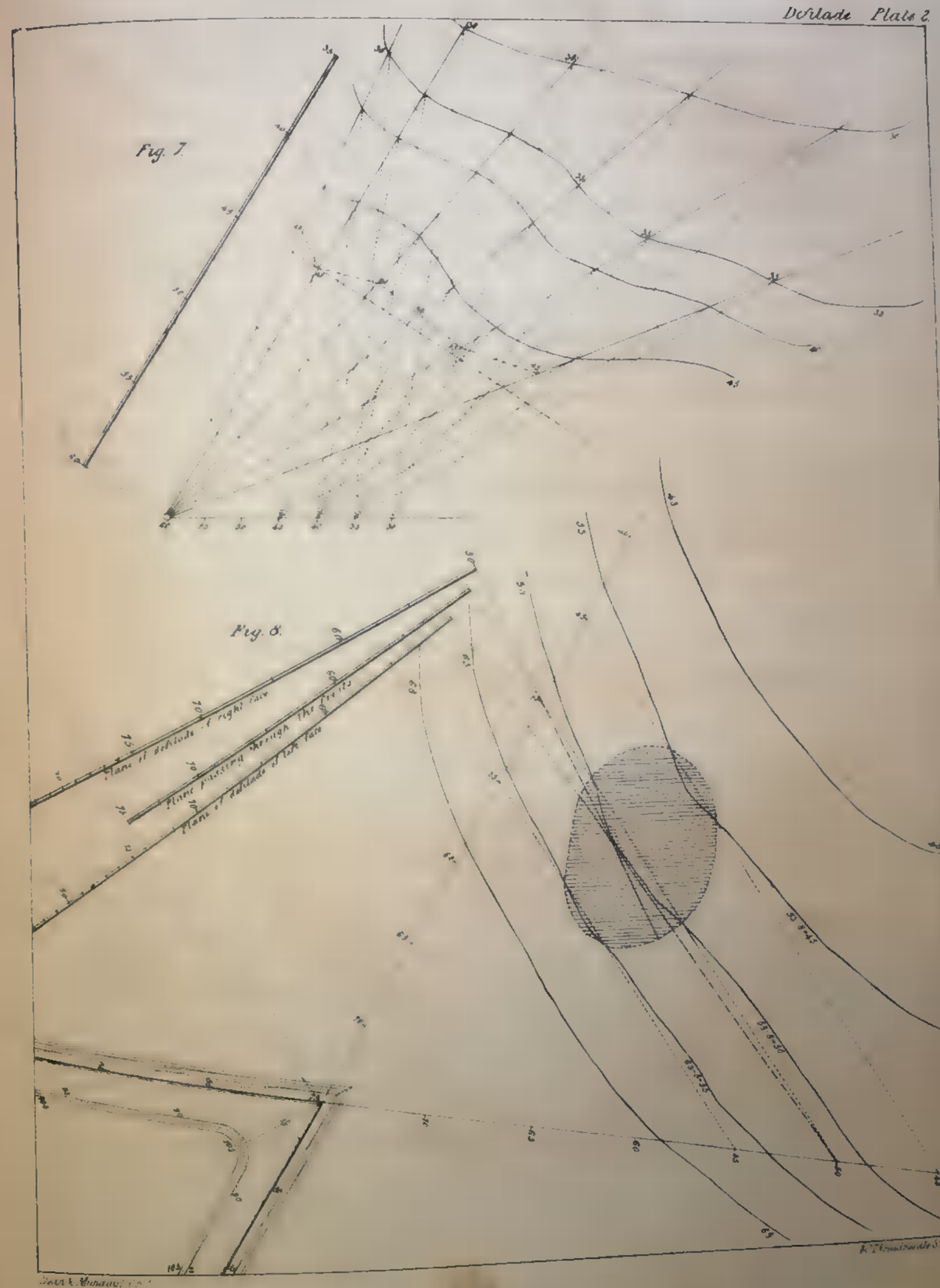
then, such planes should pass at least 8 feet above the highest but rather distant parts of the natural ground, or $3\frac{1}{2}$ feet above those parts which an enemy could not occupy without forming defences, including the parapets of advanced works within range of musquetry; the same considerations that fix the minimum command of parapets above a horizontal site, determining the vertical distance between planes of defilade and the points accessible to a besieger.

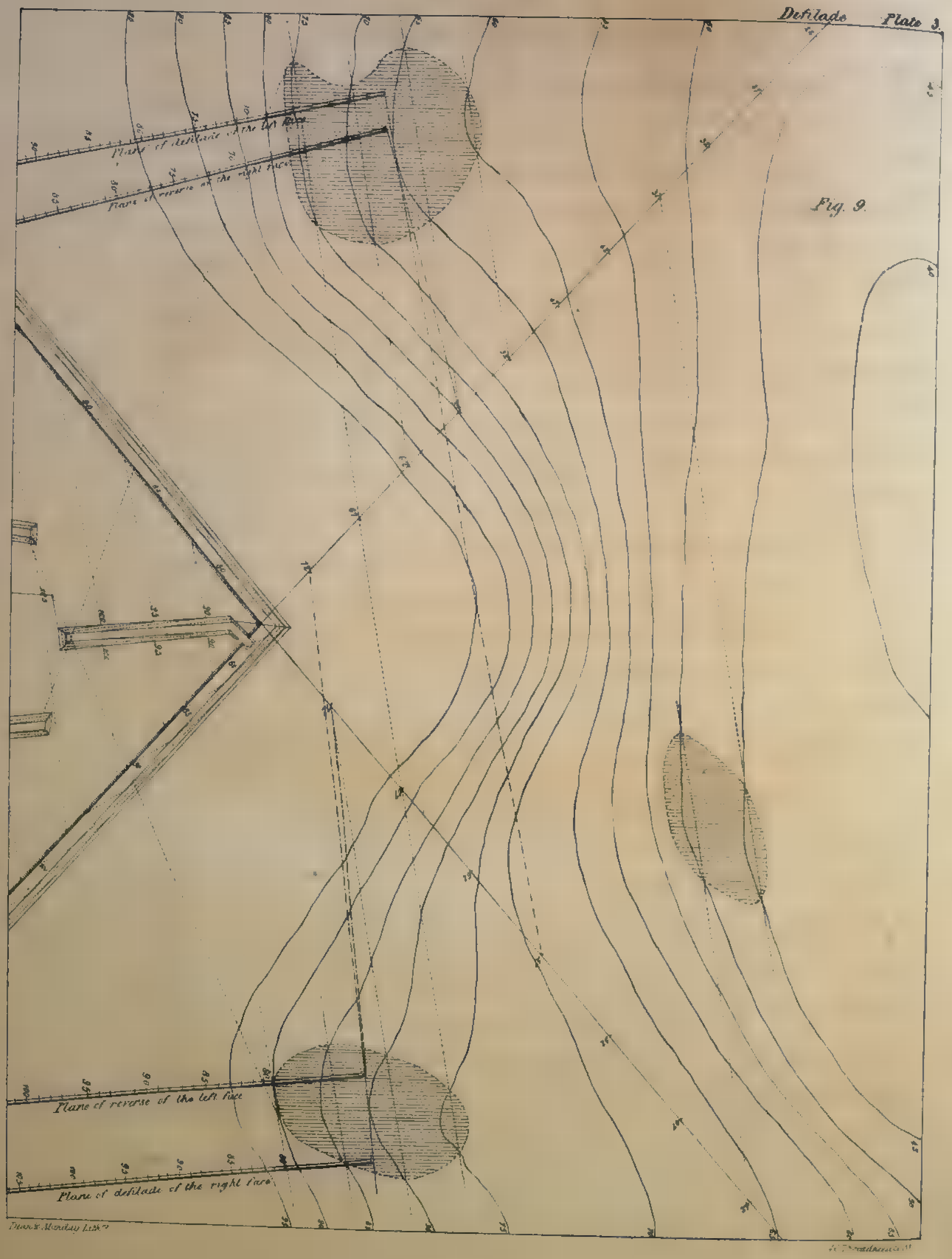
The first operation in defilading a work is to trace the limits within which an enemy can fire into it. If the work be isolated, or if the relief of other works with which it is combined be insufficient to cover it in any direction, arcs described with each salient as a centre, and the extreme effective range of the weapons likely to be used, generally 1500 or 1600 yards as a radius, will define these limits. But, if other works by their relief would intercept the view from a part of the surrounding ground, lines should be drawn through the most advanced points, both of the work to be defiladed and such protecting masses; and whatever portions are thus ascertained to be of no consequence, so far as direct fire is concerned, may be entirely disregarded in arranging the defilade; care being taken, however, to observe whether the protection afforded by another work is not merely partial, and whether from behind it, or over some part of it, that under consideration may not be exposed.

The whole of the exterior space, from which it is required to defilade a given work being marked out, the mode of proceeding will vary a little according to the conditions to be observed.

The trace and relief may be already determined; this would be the case when existing works were to be more perfectly defiladed: or the plane of defilade may be required to pass through a particular point or line, as when the position of some part of the crest cannot be varied; or when it is required to keep the plane of defilade a certain quantity below some works in rear; or when it is necessary that a communication, or the masonry of some part of the defences, should be covered: or, lastly, as must happen in cases where the greatest latitude is allowed, the form of the ground, and the adjustment of remblai and deblai, may fix a maximum and minimum command above the actual site, which must be attended to in choosing a plane of defilade.

Let it be supposed, then, that a work of two faces, forming a salient angle, has its crest finally determined. If the plane passing through that crest either cuts or leaves at less than the proper distance below it, any portion of the ground within the prescribed limits, the defilade must be arranged by sloping the terre-





pleins, or, if that be impossible, by traverses. If the points, which too nearly approach or rise above the plane of the crests, are all included between the produced faces of the work, as in *fig.* 8, neither face will be seen in reverse from such points, and by defilading each independently the whole interior of the work will be concealed: it will only be necessary to find, for each face, that plane which passing through its crest shall leave all the ground in front at a proper distance beneath, and then, by constructing the terre-pleins parallel to these planes, forming by their intersection a valley from the salient towards the gorge, the whole will be perfectly covered. Or if the terre-pleins would be thus rendered inconveniently steep, they must be lowered near the parapet, so as to obtain the same cover with diminished inclination.

If, however, the points from which shelter is required do not lie between the produced faces of the work, one of them at least, since the crest by the assumed conditions cannot be raised, will be exposed to reverse fire, and traverses must then be resorted to, as in *fig.* 9. Their positions should be so chosen as to cause the least inconvenience, and their heights determined by the plane which, passing through the crest of the face they are intended to protect, leaves at the required distance beneath, all the ground seeing it in reverse; if both faces are thus exposed, there will be two such planes of reverse, and if one traverse be constructed to cover both faces, it must of course be carried up to the highest of those planes.

A single traverse is generally sufficient, and when required only for the protection of one face, its height may obviously be made less in proportion as it is constructed near that face; leaving, therefore, sufficient space for the defenders, it may be traced parallel to the parapet until it approaches the salient, and then, in order not to impede the defence by filling up that angle, it may be turned, its height being increased, upon the second face: the traverse near the salient in *fig.* 9, shows this arrangement.

If both faces are thus exposed, the intersection of their planes of reverse marks the situation where the smallest single traverse would be sufficient, and the nearer it can be constructed to that line, the less will be the labour of its formation. But, when the faces of the work are long, and the interval between them becomes considerable at a distance from the salient, a single traverse would probably require to be raised so high, that more earth would be used in its construction than in making one for each face. In such cases, for the part near the

salient, or as far as it is advantageous, a single traverse should be employed: for the remainder of the work, one for each face, as in *fig.* 9.

When the work is narrow, as a counterguard or covered way, it may be impossible to construct a single traverse capable of covering each face; several must then be employed, care being taken that any shot which would just pass one traverse shall be intercepted by another.

Lastly, when the commanding points of the ground fall on or nearly on the produced faces, a bonnette at the salient, or traverses across the terre-plein, a different plane of defilade being employed for the part in rear of each, must be resorted to; and when the work is exposed at its gorge, a parados must be constructed there, of such length as may be necessary, and of sufficient height to cover the whole terre-plein as far as the salient.

The directions of the different traverses should always be so chosen, that they may not afford shelter to an enemy from works in rear; and when these masses are intended to afford lines of fire, as with those in the covered-way, their crests must not rise above the plane of defilade of the work in which they are constructed.

The defilade of a work already constructed, leads easily to the methods to be adopted when the reliefs are undetermined, but certain conditions have to be fulfilled. It should first be seen whether a plane cannot be found which, fulfilling the requisite conditions, shall pass at the proper distance above all the surrounding ground; the work can then be defiladed without further difficulty. But, if this cannot be done, it should be ascertained whether a plane cannot be found, still fulfilling the required conditions, passing at a sufficient height above all the ground, except such parts of it as are included between the produced faces of the work, as in *fig.* 8, supposing a work of two faces to be under consideration, as before: adopting then such plane as that of defilade for the work, each face must be seperately defiladed by its terre-plein, from the commanding points included within the produced faces. If, however, a single plane cannot be found as above, or if such plane would be impracticable from its steepness, two planes of defilade must be employed, as in *fig.* 9, one for each face, the conditions being observed by both planes, if necessary, as when the relief of the salient is in question, or partly by each, as when some points of a work in rear are to be covered; and in this case traverses must be introduced, as before described, for completing the operation.

It may happen that a single plane cannot be found for one face even, without giving it so great an inclination in the direction of its length, that the relief at one extremity would be excessive, or that at the other inadmissibly small; in this case, each face must be defiladed by steps, the different portions rising above each other by such quantity as may be found convenient.

The above appear to be all the considerations required to be pointed out; they may be briefly recapitulated by saying, that the face of a work commanded by ground in front, in rear, or on its prolongation, can be defiladed from the first by its terre-plein, from the second by a traverse, or parados, or by giving it the same plane of defilade with some other face lying between it and the point of danger; in the last case, unless the commanding ground is but little elevated, or the face under consideration short, traverses must be resorted to, and the defilade completed in portions.

In defilading a fortress composed of several bastion fronts, it should first be seen whether a plane could not be found which, reducing to an even surface the intended site, would be tangential to, or at least would not cut by more than 2 or 3 feet, the surrounding ground. If such plane could be obtained, it should be considered as the plane of site, and the commands, &c. be regulated from it according to the proposed profiles. If such a plane could not be found, either for the whole or any very considerable portion of the work, the exterior sides might be considered two and two, as two faces of a work have been above, but it would generally be necessary to defilade each separately.

Until lately, the mode of proceeding in this case was by endeavouring to obtain a single plane of site for a whole front, or, if that proved impossible, from the existence of high ground upon its flanks, two planes of site, meeting on the capital of the ravelin, were employed: it is now, however, judged expedient, wherever two or more fronts of a fortress cannot be arranged upon a common plane of site, to consider each part separately. The limits of command for a bastion being chosen, from considering the ground to be seen by it, and the equalisation of remblai and deblai, the defilade of that bastion should be completed. So far as its faces are concerned, this operation would be similar to one of those already described; but its flanks might either have the same plane of defilade as the faces they respectively join, or have their crests determined by the plane passing through both faces, or have distinct planes of defilade; the principles already laid down being quite sufficient to determine in any case

which of these arrangements should be preferred: but it may be mentioned here, that if protection from reverse fire be required for the flanks and faces of a bastion, the construction of a cavalier will generally prove the most advantageous mode of obtaining it.

Beginning, generally, with the covered-way or most advanced line of defence, its different faces may be defiladed, two and two, as above described, assuming as conditions a maximum and minimum command. After this is completed, the defence of those in front must be attended to in defilading the works in rear, as they are taken in succession. Thus, the covered-way being determined, the ravelin would be considered, its command being nearly fixed by the necessity of defending certain portions of the ground, and also its own covered-way: next, each bastion may in like manner be separately defiladed, and then the curtain, the crest of which will have been decided by the preceding operations.

The foregoing principles of course apply to field-works also, but these would almost invariably be defiladed on the spot, by some such method as the following: erect a picket at each angle, and nail two slips or fingers across it, one at the maximum, the other at the minimum command that can be allowed to its parapet; with the assistance of a straight edge, or by stretching a cord between two or more of the pickets, and varying its position, it will be readily seen what plane or planes of defilade can be obtained within the prescribed limits. If these planes are likely to prove steep, and it be therefore desirable that they should not pass above the surrounding country more than is absolutely necessary, the height at which they are required to pass, should be deducted from the maximum and minimum command of the parapet, and the slips nailed across at this reduced level; a plane tangential to the ground should then be chosen, and the crest of the parapet will be everywhere higher than that plane, by the quantity previously deducted.

The limits of defilade for field-works are different to those assigned above for permanent constructions. It is generally considered sufficient if they afford cover within the distance of 700 or 800 yards, their planes of defilade passing about 4 feet, or the height of a field-piece above such points as are out of musquet shot, and 8 feet above the ground within range of the fire-arms of cavalry.

The defilade of a work, although it is absolutely necessary that it should be perfect, is nevertheless so completely secondary to the other considerations which determine the trace, that it can rarely, it may almost be said that it can never

happen, that the trace most favourable for defilade can be given to the enceinte: the method proposed however for ascertaining the general arrangement of such trace is worth alluding to.

Assuming some point nearly in the centre of the space to be occupied by the works, and through which it appears convenient that the planes of defilade should pass, find the most advantageous plane or planes passing through it, and also at the due distance above the surrounding ground; these will represent nearly the easiest planes of defilade that can be obtained; and their intersections with two surfaces parallel to the site, but higher than it by the quantity assumed as the maximum and minimum command, will give two outlines enclosing a belt or zone, within which the trace should be confined.

The above rule is founded on the supposition that the best trace for a given site is that in which, when defiladed, the commands are most nearly uniform; and although it may be impossible to attend to it throughout the whole of a design, there will generally be some parts where its principle can be observed.

If a line of works were to be constructed on horizontal ground, in front of a commanding ridge also horizontal, it is evident that the intersection of a descending plane, resting on that ridge, with the ground, would be parallel to the ridge; and therefore, to obtain when defiladed a uniform command, the general direction of the works should be parallel to it. If the ridge were higher at one end than at the other, the horizontal of the descending plane, resting on it as before, would recede from the higher, approaching the lower extremity; its intersection with the supposed site would therefore do so, and such should be the direction of the trace. If the ground to be occupied had an inclination either from or towards the heights, but in such directions that its contours were parallel to those of the plane assumed as above, the trace would be the same as on horizontal ground; but if the contours of the ground were inclined to those of the plane, the trace should recede from the ridge as it descends upon the site.

This paper being written for the purpose of drawing attention to the advantages resulting from the use of contoured plans, rather than discussing fully a subject connected with fortification, might here be concluded; but as it may be said that there is great difficulty in preparing such plans, while in fact they are as easily executed as those now required, where numerous vertical sections are substituted for a single drawing, a brief description of a mode of obtaining them shall be added.

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which of these arrangements should be preferred: but it may be mentioned here, that if protection from reverse fire be required for the flanks and faces of a bastion, the construction of a cavalier will generally prove the most advantageous mode of obtaining it.

Beginning, generally, with the covered-way or most advanced line of defence, its different faces may be defiladed, two and two, as above described, assuming as conditions a maximum and minimum command. After this is completed, the defence of those in front must be attended to in defilading the works in rear, as they are taken in succession. Thus, the covered-way being determined, the ravelin would be considered, its command being nearly fixed by the necessity of defending certain portions of the ground, and also its own covered-way: next, each bastion may in like manner be separately defiladed, and then the curtain, the crest of which will have been decided by the preceding operations.

The foregoing principles of course apply to field-works also, but these would almost invariably be defiladed on the spot, by some such method as the following: erect a picket at each angle, and nail two slips or fingers across it, one at the maximum, the other at the minimum command that can be allowed to its parapet; with the assistance of a straight edge, or by stretching a cord between two or more of the pickets, and varying its position, it will be readily seen what plane or planes of defilade can be obtained within the prescribed limits. If these planes are likely to prove steep, and it be therefore desirable that they should not pass above the surrounding country more than is absolutely necessary, the height at which they are required to pass, should be deducted from the maximum and minimum command of the parapet, and the slips nailed across at this reduced level; a plane tangential to the ground should then be chosen, and the crest of the parapet will be everywhere higher than that plane, by the quantity previously deducted.

The limits of defilade for field-works are different to those assigned above for permanent constructions. It is generally considered sufficient if they afford cover within the distance of 700 or 800 yards, their planes of defilade passing about 4 feet, or the height of a field-piece above such points as are out of musquet shot, and 8 feet above the ground within range of the fire-arms of cavalry.

The defilade of a work, although it is absolutely necessary that it should be perfect, is nevertheless so completely secondary to the other considerations which determine the trace, that it can rarely, it may almost be said that it can never

happen, that the trace most favourable for defilade can be given to the enceinte: the method proposed however for ascertaining the general arrangement of such trace is worth alluding to.

Assuming some point nearly in the centre of the space to be occupied by the works, and through which it appears convenient that the planes of defilade should pass, find the most advantageous plane or planes passing through it, and also at the due distance above the surrounding ground; these will represent nearly the easiest planes of defilade that can be obtained; and their intersections with two surfaces parallel to the site, but higher than it by the quantity assumed as the maximum and minimum command, will give two outlines enclosing a belt or zone, within which the trace should be confined.

The above rule is founded on the supposition that the best trace for a given site is that in which, when defiladed, the commands are most nearly uniform; and although it may be impossible to attend to it throughout the whole of a design, there will generally be some parts where its principle can be observed.

If a line of works were to be constructed on horizontal ground, in front of a commanding ridge also horizontal, it is evident that the intersection of a descending plane, resting on that ridge, with the ground, would be parallel to the ridge; and therefore, to obtain when defiladed a uniform command, the general direction of the works should be parallel to it. If the ridge were higher at one end than at the other, the horizontal of the descending plane, resting on it as before, would recede from the higher, approaching the lower extremity; its intersection with the supposed site would therefore do so, and such should be the direction of the trace. If the ground to be occupied had an inclination either from or towards the heights, but in such directions that its contours were parallel to those of the plane assumed as above, the trace would be the same as on horizontal ground; but if the contours of the ground were inclined to those of the plane, the trace should recede from the ridge as it descends upon the site.

This paper being written for the purpose of drawing attention to the advantages resulting from the use of contoured plans, rather than discussing fully a subject connected with fortification, might here be concluded; but as it may be said that there is great difficulty in preparing such plans, while in fact they are as easily executed as those now required, where numerous vertical sections are substituted for a single drawing, a brief description of a mode of obtaining them shall be added.

Trace, by placing a picket at each extremity, one at the upper another at the

lower, those lines which best define the ground, or every sensible ridge and valley, and as many others as may be convenient when the surface is curved without any apparent angles. Fixing then a level in a good position, over one of the points in the contour to be traced, and where a tolerable length of it can be seen, send an assistant with a levelling-staff set to the height of the instrument, to stand between the pickets of the nearest line traced out, a second assistant keeping him in the line of those pickets, while the observer at the instrument moves him by signal up or down the slope, until they are on the same level: having marked this point, the first assistant places himself between two other pickets, and the operation is repeated until as many points have been marked as can be observed with one position of the instrument, when another is chosen.

The required number of contours being thus traced out, it is only necessary to fix the extremities of the different lines with reference to each other, and to measure them horizontally, noting the different marks laid down.

The general plan for forming a design may be made to a scale of about 200 yards to an inch, with contours at vertical intervals of about 5 feet; but it is not necessary that all the ground within the limits of defilade should be contoured; the whole of the immediate site of the work should be thus described, and any slopes in the vicinity which might affect the command independently of defilade: with respect to the heights around the work, it will be sufficient to give a few contours of each, beginning from their summits, and of course on the side towards the plane alone; the levels of a good many points of the remaining space should then be added.

Such a plan being employed for the general design, the details of each front may be completed on similar drawings, made to a scale of about 30 yards to an inch.

X.—*Report on the Manchester, Cheshire, Staffordshire, and the South Union Lines of Railway (by order of the Master-General and Board of Ordnance.) By Captain* Alderson, *Royal Engineers.*

London, 24th April, 1837.

Sir,

In obedience to the orders of the Master-General and Board, dated 20th March, 1837, to report on the general nature, in an engineering point of view, of the two competing lines of Railway, the one promoted by a company called the Manchester, Cheshire, and Staffordshire Railway Company, and the other by a company called the South Union, I have the honour to report, for the information of the Master-General and Board, as follows:—

Both lines commence from the same terminus, nearly, in Store-street, Manchester.

The situation appears to me well chosen, it is central, and the part of the town through which the lines propose to pass consists of buildings of comparatively small value.

Each line commences with a viaduct, extending from the terminus to the end of the town, and crossing the river Medlock in its progress.

The Manchester, Cheshire, and Staffordshire line then crosses the turnpike-road to Sheffield, about $1\frac{1}{4}$ mile from the terminus, without altering its present surface, and passing the Gorton brook, leaving Longsight on its right, crosses the road to Stockport, which is to be lowered 9 feet 3 inches,

It thence, leaving Levenshulme to its right, comes to some considerable cutting, which can be employed in filling up the valley of the Mersey, which river it crosses by a viaduct, eight chains below Brinksway-bridge, being within the borough of Stockport.

The line then crosses the road from Stockport to Cheadle, which is to be lowered 22 feet, and comes into a considerable embankment for near two miles, which is followed by an equal portion of cutting, from which the embankment may be formed.

It then crosses the river Dean, and continues in cutting till it arrives at the river Bollin, which it crosses about ten chains above the town of Wilmslow: both

these streams are inconsiderable, and have stone bridges across them near these places, of one arch each.

After crossing the Bollin at Wilmslow, the line runs on favourable ground till it arrives at the river Dane, at the town of Congleton; where a viaduct of considerable length will be required, on piers varying from 50 to 100 feet in height, passing over the river, valley, and main street of Congleton.

This work is the greatest, in an engineering point of view, on this half of the line; it presents, however, no difficulties, the banks of the river affording good foundations for the piers.

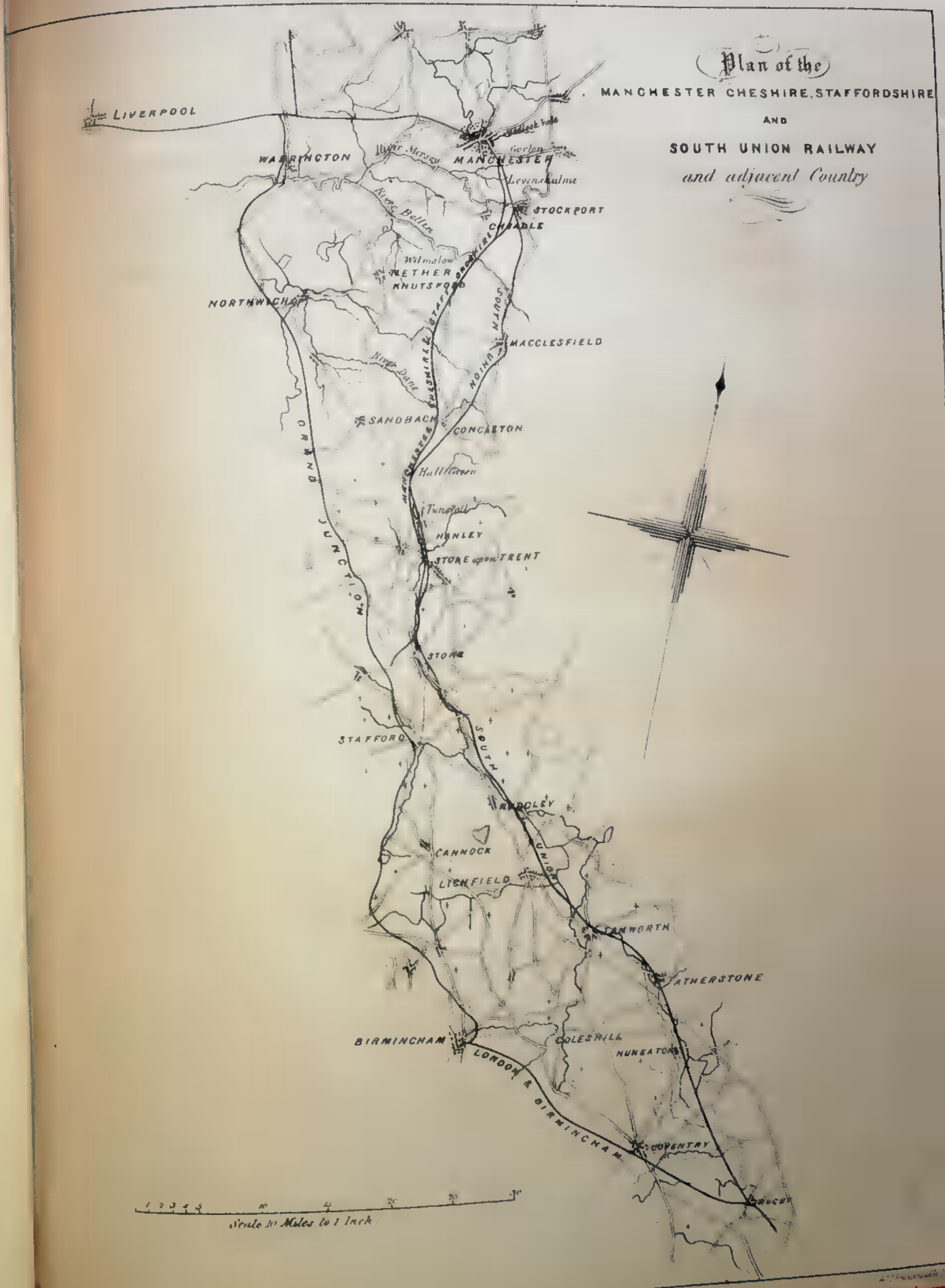
The line then continues in a straight line to Oak Farm, within about 300 yards of the Macclesfield Canal, to which it runs nearly parallel, till it arrives at Hall-green, when it crosses the canal at a considerable angle, taking a more direct course to its summit level at Harecastle Pass, when it again runs close to, and between the canal and New Church at Woolstanton, and commences its tunnel of 440 yards in length near to the lodge of Clough Hall, and arrives at its summit level 440 yards beyond the tunnel, in heavy cutting, averaging 35 feet in depth, in 29½ miles, having risen 290 feet; its greatest inclination being 1 in 378, or 14 feet to a mile.

As both lines meet at this point, I propose to consider their relative merits to it in the first instance.

The South Union line, from the end of the viaduct at Manchester, runs on the east side of the turnpike-road to Stockport, about 12 chains distant, and nearly parallel to it for 3¼ miles, when it crosses the road, which has to be lowered 7 feet, and goes direct for Stockport, having been for the last mile in cutting averaging about 14 feet deep; it then crosses the river Mersey, about eight chains below the Wellington-bridge, by an extensive viaduct on piers, between 80 and 90 feet above the level of the river, and passing over some of the buildings in the town, situated on the sloping banks of the river; at the upper end of the town it goes into cutting for about 3 miles, followed by embankments and cuttings alternately.

Within 2½ miles of Macclesfield, there are some short steep hills to be cut through, and one tunnel of 200 yards in length; after which it crosses the river Bollin, which, 1½ mile back, has to be diverted or otherwise twice crossed; after cutting through another short steep hill, it enters the town of Macclesfield, again crossing the Bollin over Beach-bridge, which has to be raised 11 feet.

It then crosses eight streets, all of which have to be raised from 1 to 16 feet,



and again crosses the Bollin frequently, or in some places follows its course, it being intended, I understand, to divert the river by tunnelling it under the adjoining street, the line being here from 12 to 16 feet below the level of its bed.

The line thus traced through the town of Macclesfield appears to be attended with considerable difficulties and great expense. On leaving the town it rapidly increases in the depth of its excavation; and, after destroying a large reservoir of water, and crossing the turnpike-road 62 feet below its surface, enters upon Dean's Moss.

The cutting through this moss is about 2¼ miles, its greatest depth 86 feet and averaging 55 feet throughout, giving upwards of 3,000,000 cubic yards; the whole of which must be run out on the adjoining land, not being required for embankment.

As this is a work of considerable magnitude, and about which much has been said, I shall endeavour to state my own impressions on examining it.

On crossing over this part of the line, which, in its present state, is attended with some inconvenience for the want of drainage, I observed that wherever surface-drains had been cut, and some of the turf removed, the remainder was perfectly dry, and showed a vertical section quite firm, the water having left it for the drains or excavations made by removing the turf; and I therefore think, by good surface-drains, and by running in drifts at both ends, so as to give vent to the water, the drainage may be effectually secured, and the work proceeded with, without any fear as to the result.

From the strata, as exhibited by borings shown me by one of Mr. Stevenson's assistants at Macclesfield, extending from 40 to nearly 100 feet in depth, and from which I understand a geological section has been made, I consider it may be compared to a pond filled with vegetable matter and water resting on gravel, sand, or marl, and when tapped at the level of the bottom of the pond, with the assistance of surface-drains, that the water will pass off.

Having heard of the difficulties that had arisen at the Kilsby tunnel, on the London and Birmingham line, by coming into a vein of quick-sand with water, and as this might guide my judgment with respect to those likely to occur in the above undertaking, I went to inspect it. On going down one of the working shafts, where they had met with the running sand, I found this vein giving out the water very freely, which they were collecting and pumping up with the steam-engine; at the same time they were working 40 feet below, in the blue shale perfectly dry.

It appears to me, therefore, if this had been an open cutting, or if time could have been allowed to work this tunnel from the ends only, that, had they come upon the stratum of sand, it might have been drained off, at a comparatively small inconvenience or expense; but it is necessary in a tunnel of this length to commence in several places at once, in order that one part may not delay the opening of the line; and the shafts, required afterwards for the ventilation of the tunnel, but sunk now for the above purpose, become so many wells, causing the difficulties encountered in the tunnel alluded to. The masterly and scientific manner in which they have been completely overcome, reflects great credit on the engineer employed.

I need scarcely add, that in an open cutting like Dean's Moss (if I am correct in my view of the case) these difficulties need not occur.

With respect to the foundation to be obtained for the rail-road at the required level, both from the borings and the geological features of this part of the country (being of the new red sand-stone formation nearly at the edge of the coal measures), I do not see any reasonable grounds for being under any apprehension as to the result.

That a work of such magnitude must be attended with very heavy expense is quite certain; and, when the immense surface of the slopes of this cutting is considered, and the quantity of water they must receive during a heavy fall of rain, it will be found that a large sum will be required to effect the drainage; and the difficulties of adopting arrangements for this purpose are the greater, from the inclination of the line through Dean's Moss being almost entirely in one direction, and that, too, towards the town of Macclesfield.

I am not aware how the engineer proposes to carry this work into effect, but from his knowledge, talent, and experience, there is no doubt of his adopting the most effectual means.

Still I cannot but consider the four miles, from the sixteenth to the twentieth, as presenting difficulties, in an engineering point of view, of no ordinary kind, and to be avoided, if practicable.

The line, after passing Dean's Moss, has nearly a mile of cutting, averaging 28 feet in depth, and then crosses the river and valley of the Dane by a viaduct, which, although considerable, is much less than the crossing of the same river on the other line; it then has about half a mile of cutting, averaging 25 feet in depth, and crosses two vallies, one upwards of 100 feet in depth, with a brook running through the bottom.

It again encounters some deep cutting, between the 28th and 30th mile, about 1½ mile, averaging 26 feet in depth, when, after a short embankment, it arrives at the tunnel at Harecastle Pass, and thence to the Bath Pool, the summit level of the other line; having gone 31 miles 6 chains, and risen in the first 19 miles 48 chains to its summit level at Dean's Moss 312 feet; and from thence to Bath Pool fallen 22 feet, its greatest slope being one in 264, or 20 feet to a mile, and having for the last five miles been on a level.

On comparing these two routes from their common terminus at Manchester to the Bath Pool, I am of opinion, that the Manchester, Cheshire, and Staffordshire Company have taken the more direct, cheaper, and easier-constructed, as well as easier-working, line.

The greatest work on this line is the viaduct over the Dane, at Congleton; but I consider the crossing of the Mersey and the Dane on this line to be on a par with the crossings of both those rivers, including the heavy embankment across the valley and brook between the 24th and 25th mile, on the South Union line; and that the tunnel, before entering the town of Macclesfield, together with the difficulties in getting through that town, and the immense cutting through Dean's Moss, to be the additional work against the South Union line between these two points, viz. the terminus at Manchester and Harecastle Pass: and besides this important difference in the cost of construction, the additional 1 mile 46 chains of distance, the additional rise of 22 feet, the greater inclination of the steepest slope, and generally of this portion of the line, must be considered as disadvantages affecting, permanently and materially, the expense of conveyance upon it.

From the Bath Pool I will now trace the two lines to their respective junctions with the Grand Junction Railway.

The Cheshire and Staffordshire line having got through its heavy cutting in the Harecastle Pass, crosses the Grand Trunk Canal, in the parish of Tunstall, about a quarter of a mile from the mouth of the tunnel of the canal, and runs through the Potteries nearly parallel to the canal.

At the town of Shelton there are several engineering difficulties to be overcome; some heavy cutting between the 33rd and 34th mile; and in a little more than one mile, between the 33rd and 35th miles, six turnpike or tram-roads to be passed over or under the line, besides tunnelling under the canal.

The line then crosses the river Trent, and, running along the east side of the Grand Trunk Canal, and nearly parallel to it, passes, at the back of Stone,

across a valley and brook requiring a viaduct; and, after encountering some cutting, crosses the turnpike-road to Rugeley, and re-crosses the canal and river Trent with its valley, requiring both a viaduct and considerable embankment; comes between the 45th and 48th miles to some heavy cutting about two miles in length, and averaging 32 feet in height throughout; when, after passing the river Sowe, it joins the Grand Junction Railroad at Rickerscote, in 21 miles 31 chains, having descended from its summit level at Harecastle Pass 191 feet 3 inches, with no inclination greater than 1 in 378, or 14 feet to a mile, having two miles on a level.

The South Union line, after getting through a similar cutting as the Cheshire line in the Harecastle Pass, keeps on the west side of the Grand Trunk Canal, passing close to Longport and Etruria, having nearly 4 miles of embankment, averaging 16 feet throughout, part of which will be performed by the deep cutting in the Harecastle Pass, and the remainder from side cutting.

It then crosses the Grand Trunk Canal about midway between Etruria and Stoke-upon-Trent, immediately in rear of this latter town; and crossing the river Trent, takes very nearly the same line as the Cheshire junction: a little past the 42nd mile it interferes with a bend in the canal, which it is proposed to divert, but which I think may easily be avoided.

The Cheshire line does the same, and they have re-surveyed it, and shown me a sketch, in which they propose to pass to the east of it.

At about the 43rd mile, close to Meaford Old Hall, it sends a branch into the Grand Junction Railroad, re-crossing for that purpose the Grand Trunk Canal, and river and valley of the Trent, which is much narrower at this point than where the other line crosses, after which it encounters about two miles of cutting, averaging 20 feet in depth, and enters the Grand Junction Railroad at Hamner Houses, $7\frac{1}{4}$ miles short of the Cheshire and Staffordshire line; having gone 15 miles 74 chains, and descended 159 feet, with no slope greater than 1 in 349, or about 15 feet to a mile, and having $2\frac{1}{2}$ miles on a level.

On comparing these two routes from Harecastle Pass to their respective junctions with the Grand Junction Railroad, I am of opinion, the South Union line is the cheaper and more direct communication with the Grand Junction Railroad; it avoids the engineering difficulties in Shelton, as well as the uneven section behind Stone; crosses the valley of the Trent with a shorter viaduct and embankment, and has a much less heavy cutting between that and its junction,

which is effected in 5 miles 38 chains less distance, in addition to its other advantages.

The Cheshire junction, in order to save 1 mile 63 chains, has to make 5 miles 38 chains additional railroad, under unfavourable circumstances, and without a corresponding advantage between Manchester and Birmingham.

At the same time it is right to state, though I decidedly give the preference to this half of the South Union line, I do not think there is that *amount of difference* in an engineering point of view between them, that I find in the first half on the opposite side.

The following is a comparative statement of the two competing lines in point of distance, together with that of the substitution of such portions of each as I have here considered as presenting the least difficulties in an engineering point of view:—

	Miles.	Chains.
From Manchester to Rickerscote, by the Cheshire and Staffordshire line,	50	71
From Manchester to Hamner Houses, by South Union line	47	0
From Hamner Houses and Rickerscote	7	20
	54	20

* From Manchester to Bath Pool, by the Cheshire and Staffordshire line, and thence to Hamner Houses, by the South Union line . .	45	34
From Hamner Houses to Rickerscote	7	20
	52	34

Thus, by making 45 miles 34 chains of railroad, and joining the Grand Junction at Hamner Houses, the communication between Manchester, Birmingham, and London is completed.

In the opinions I have given relative to these two routes, I trust I shall not be considered as calling in question the skill and talent of the engineers employed, their high characters and reputation would cause such an imputation to recoil on myself; but I am well aware, that in laying out lines of railroad, in order to

* The Committee of the House of Commons having declared themselves in favour of this joint line, the two companies agreed to unite, each withdrawing the half of their line thus objected to; the new formed company to be called the Manchester and Birmingham Railway Company.

obtain support from towns on the line, as well as from influential individuals whose property is affected, an engineer is compelled to deviate from that route which (considered professionally only) he would otherwise recommend.

In compliance with further orders from the Master-General and Board, dated 5th April, 1837, I shall now proceed to report on the remaining portion of the South Union line, from where it sends its branch into the Grand Junction Railroad, to its terminus at Tamworth, as well as on a projected line of railroad between Tamworth and Rugby, where it joins the London and Birmingham Railroad; and then consider the respective merits of both lines, viz.:

The Manchester, Cheshire, and Staffordshire line, *via* Birmingham and the South Union line, *via* Tamworth and Rugby, from which latter place they both take the same route to London.

The branch near the 43rd mile leaves the main line, in cutting which continues for about a mile, taking the same line as the Cheshire and Staffordshire line, crosses between the 43rd and 44th mile the turnpike-road to Leek, which has to be raised 7 feet, and then crosses the brook and valley behind Stone; it then runs nearly on the surface, till it crosses the turnpike-road to Stafford 13 feet above it, requiring it to be lowered 6 feet; when it comes into embankment for 1½ mile averaging 16 feet, and after cutting through a short steep hill, and diverting two cross-roads, crosses the Grand Trunk Canal and the river Trent with a trifling embankment, just sufficient to pass the canal without difficulty; a short cutting follows from which this embankment may be formed.

The line then runs for five miles with slight embankment, and comes into two miles of heavy cutting through sand, stone, and marl, averaging 36 feet throughout, when about two miles of slight embankment brings the line to Colton Mill; it previously, however, opposite Bellamore, encounters a bend in the Grand Trunk Canal, which is to be diverted.

Leaving the town of Rugely on its right, it has a short steep hill to cut through, when it runs parallel to the river Trent, about twelve chains from its right bank.

Between the 59th and 60th mile it again crosses the Trent, and, in less than one mile further, the Grand Trunk Canal; it then passes to the left of Handsacre Hall, crossing two turnpike-roads from Litchfield to Rugely, and continues on favourable ground, with the exception of about half a mile of cutting about the 65th mile, until it arrives at the town of Whittington, through part of which it passes.

It soon after meets with a bend in the Coventry Canal, which it is proposed to divert by straightening it with embankment.

The line, then passing in front of Tamhorn House, crosses the river Tame, here about 35 yards wide, with a gravelly bottom and good banks; it then crosses Staffordshire Moor in slight embankment, and arrives close to Tamworth, crossing the road to Ashby-de-la-Zouch, at the outskirts of the town, in cutting from 20 to 25 feet in depth, and arrives at its terminus on the banks of the river Anker, 24 feet below the Derby and Birmingham Railroad, which crosses it nearly at right angles, in considerable embankment.

This line, from the point where it sends its branch into the Grand Junction Railroad to its terminus, has gone 28 miles 26 chains; its greatest inclination being 1 in 331, or 16 feet to a mile (which continues 1½ mile only), having descended 130 feet, and ascended between the 52d and 63d miles 26 feet, and having gone eleven miles on a level.

I will now trace the proposed line of railroad, commencing at the South Union terminus at Tamworth, to its junction with the London and Birmingham Railroad at Rugby.

This line crosses the river Anker immediately it leaves its terminus, and for three miles runs on favourable ground; it then re-crosses the Anker, and has to pass under the road from Poleworth to Warton, 64 feet below its level. As this hill is short, a tunnel might be found advisable.

For the succeeding thirteen miles it continues in the valley of the Anker, on very favourable ground, frequently crossing this small stream, and which I should suppose, in the four crossings between the 11th and 12th miles, would either be wholly diverted or converted into two crossings.

At the 13th mile it passes immediately at the back, and to the eastward of the town of Nuneaton, and one mile further that of Attleborough, crossing four roads which have to be raised considerably, and the Ashby Canal; and soon after the 15th mile passes through the back part of the town of Shilton to the westward of the church, being in cutting from 16 to 33 feet in depth.

The line now enters upon a more uneven section, having to cross over a number of short hills and vallies, round which the Oxford Canal used to run, but which has now been much shortened by cuttings and embankments.

The old Oxford Canal, here represented to be crossed so frequently, excepting in two places, does not exist.

At the 24th mile the line crosses the Oxford Canal, and one mile further the old canal (used as a branch,) where the road to Newbold-upon-Avon crosses, and

leaving that town to the eastward, enters the valley of the Avon, which river it twice encounters, but which may be made into one crossing, and then joins the London and Birmingham Railroad between the 82nd and 83rd mile from London, near Rugby, in about 18 feet embankment; having gone about 26½ miles, and risen 137 feet to its summit level near the 18th mile, including a fall of 6 feet between the 4th and 8th miles, and from thence fallen 28 feet to its junction with the London and Birmingham Railroad, its greatest inclination being 1 in 396, or rather more than 13 feet to a mile, and having 2 miles on a level.

In reporting on this portion of the proposed communication between Manchester and Rugby, viz. from Meaford Old Hall to Tamworth, and thence to Rugby, through the vallies of the Trent, Tame, and Anker, I am of opinion that, both from its inclinations and the directness of its route, (the curves being all good, and a considerable portion of the line between Tamworth and Rugby nearly straight,) also from the absence of extensive and laborious engineering undertakings, it will be an easily and cheaply constructed, as well as good working line; and that the country through which it passes is well adapted for railroad communication.

The road, river, and canal crossings appear to be the greatest works on the line; the former, occasioned by the line being so near the surface, obliging the roads to be raised considerably; and the two latter, from their frequency, as well as occasionally requiring to be diverted.

It is apparent, too, that in one or two cases, in passing through the valley of the Trent, the ornamental property, which abounds here to a considerable extent, has obliged the engineer to deviate from that route which, considered profesionally, he would otherwise have adopted; and the most extensive cutting on the line, as well as one or two additional river and canal crossings, would appear to have been occasioned by these deviations; but in a valley of this kind, it is only extraordinary that this does not occur more frequently.

Having now reported on the projected lines of railroad of both companies, from their common terminus at Manchester to where they respectively avail themselves of railroad communication already formed; and having also examined that railroad between those respective points, viz. Rickerscote on the Grand Junction, and Rugby on the London and Birmingham Railroads; I will now proceed to show the advantage gained by the South Union Company, in point of distance between Manchester and Rugby, and the additional length of railroad to be constructed to obtain this advantage.

By the Manchester, Cheshire, and Staffordshire line:—

	Miles.	Chains.
From Manchester to Rickerscote	50	71
From Rickerscote to Birmingham	27	40
From Birmingham to Rugby	28	60
Total	107	11
By the Manchester South Union, &c.		
From Manchester to Tamworth	71	46
From Tamworth to Rugby	26	36
Total	98	2
Leaving in favour of the latter route	9	9

In addition to which the difference of the inclinations on each route must be taken into calculation, as shown in the following table:—

Ascents and Descents on each Line of Railroad from their common terminus in Manchester to Rugby.

From Manchester to Rugby.	Ascents. Feet.	Descents. Ft.
Manchester to Rickerscote	290	191·3
Rickerscote to Birmingham	216	117
Birmingham to Rugby	111	158
Total	617	66·3
By the *Manchester South Union.*		
Manchester to Tamworth	348	304
Tamworth to Rugby	137	34
Total	485	338
Leaving in favour of the latter route	132	128·3

The descents going south become ascents going north; according, therefore, to Mr. Stevenson's calculation, in his Report on two proposed lines of railroad between Glasgow and Ayrshire, that 20 feet of rise is equal to a mile of horizontal distance, (which, though I do not quite subscribe to, may be considered a tolerable approximation to the truth,) we shall have (averaging both ways) about 6 miles 40 chains, which, added to the 9 miles 9 chains of actual distance,

will give something more than 15½ miles between Manchester and Rugby in favour of the South Union line.

To obtain therefore this advantage of 15½ miles between Manchester and London, and to give also a communication to Birmingham, the South Union line proposes to make 101 miles 72 chains of railroad.*

The Cheshire and Staffordshire line, abandoning this advantage of 15½ miles, completes the communication between Manchester, Birmingham, and London, in 50 miles 71 chains, by making use of the Grand Junction and London and Birmingham Railroads already formed, saving thereby the construction of 51 miles 1 chain of railroad.

In conclusion, I beg to state, the plans and sections from which I have taken the foregoing distances are constructed on small scales, and some allowance must therefore be made for trifling inaccuracies.

I have the honour to be, Sir,

Your most obedient humble servant,

R. ALDERSON,

Captain, Royal Engineers.

To the Inspector-General of Fortifications, &c.

Opinion upon the South Union and the Manchester and Cheshire Junction Railways. Captain ALDERSON, *Royal Engineers.*

SIR, London, 8th May, 1837.

IN obedience to the Master-General and Board's order, dated 3rd May, 1837, $\frac{C}{2232}$, calling for my opinion on the two Reports transmitted with the accompanying letter from Lord Francis Egerton, Chairman of the South Union and Manchester and Cheshire Railways, I have the honour to report, for the information of the Master-General and Board, as follows:

In my former Report on these two lines of railway, I did not express an opinion on the deviation line of the Manchester and Cheshire junction, commencing a little beyond the third mile, and crossing the river Mersey at Stock-

* The extension of the South Union line from Stone to Tamworth, and thence to Rugby, was thrown out by the Committee a day or two before this Report was sent in.

port, at the same place as the South Union line, but 20 feet below it, and rejoining the main line between the ninth and tenth mile from Manchester. I examined it, however, so as to enable me to do so at a future period, should it be required; and have now to state that, excepting the additional expense to be incurred in crossing the river at this place, and the purchase of the ground through the town, I see no objection to its becoming a portion of the main line, instead of the route by the Brinksway-bridge, particularly as, in the proposed branch from Stockport to Macclesfield, it is considered essential to pass by the Poynton and Adlington collieries; and, with this understanding, I will now examine the reports of the two engineers, in which this object is proposed to be obtained by different routes.

Both parties have adopted Mr. Stephenson's line between Stockport and Macclesfield, as the basis of their reports.

Mr. Stephenson also proposes his line from Manchester to Stockport, by which he crosses the river Mersey 20 feet above the required level for the main line, *via* Wilmslow and Congleton, which 20 feet he proposes to overcome by a descent of 1 in 377 south from Stockport, until it meets the main line, which, being an ascending slope, is accomplished in one mile.

Mr. Rastrick, on the other hand, proposes his line between Manchester and Stockport, which, being a portion of the main line, he avoids any alteration to it, but has to rise 20 feet at Stockport to join the branch from Stockport to Macclesfield, which he also accomplishes in one mile; but which, being on an ascending slope, obliges him to have an inclination of 1 in 150.

It appears to me, therefore, that the comparison between these two reports may be thus drawn.

Mr. Stephenson interferes with the main line to its disadvantage, by ascending 20 feet more than is required for it, in that portion of the line between Manchester and Stockport where the greatest traffic will occur; and again, by having to descend the 20 feet between Stockport and Harecastle (causing a corresponding rise in the opposite direction), excludes the coals from the Harecastle collieries, which, by having a descending slope along the whole line, might be enabled to compete, in the Stockport and Manchester markets, with those from the Poynton and Adlington collieries, and thus prevent monopoly.

By thus altering the main line, fresh assents from the proprietors and

occupiers become necesssary, and the passing of the Bill of the Manchester and London Railroad this session is thereby rendered doubtful.

Mr. Rastrick, by not interfering with his main line, avoids these serious objections; but, in order to connect his branch with it, proposes an additional mile of railroad, at an inclination of 1 in 150, descending towards Stockport to within a quarter of a mile of the station on the left bank of the Mersey.

This is no doubt a considerable inclination; but when it is considered that the branch line falls from the collieries to Stockport, and that all the heavy traffic is in this direction, and that a considerable portion of this heavy traffic is not to descend this steep slope, but be delivered at what he calls the Coal Station; and further, that the passenger traffic is of a limited extent, being merely that between Macclesfield and the terminus at Manchester; I think there is no doubt that the line, as thus laid out, will be fully equal to the traffic it is likely to have upon it.

I am further induced to come to this conclusion, from the fact of the slopes of the two termini at Liverpool on the Manchester and Liverpool line, through the passenger, as well as the other, tunnel being considerably greater; the trains descend notwithstanding, with the use of the "brake" only, without accident.

In thus considering these two reports, I am induced to give the preference to Mr. Rastrick's;* it upholds a principle from which I think there should scarcely ever be a deviation; viz. that a main line should not be injured to benefit a branch..

Having given an opinion on these two Reports, I trust I shall not be considered as outstepping my duty in calling the attention of the Committee to the fact, that the line between Stockport and Macclesfield was laid out in its present form as a portion of the main line between Manchester and London; and for this important object, it became imperative on the engineer to select the best and most direct line for a first-class passenger-train in both directions, without reference to expense; and it is evident, when the nature of the ground is considered, this has been accomplished in a most judicious manner: but, as the present object of this portion of the line is much more limited, the heavy traffic being all in one direction, and the passenger traffic that of one town only; and, as in order to accommodate itself to the main line (if the Committee finally determine on

* The Committee adopted this opinion, and the Joint Company therefore withdrew the other Report. The different points in dispute being thus amicably arranged, the Manchester and Birmingham Railway Company obtained their Bill during the session.

that line as here recommended), it must commence at a 20 feet lower level; it becomes, I think, very possible that, on a re-survey of the ground, a more equal distribution of this additional 20 feet may be effected than is proposed in either of the present reports (still keeping in view the accommodation to the collieries), as well as a more economical line; particularly in the two miles immediately preceding its arrival at Macclesfield, where it enters the valley of the Bollin, and where, by continuing in it to its terminus, it may avoid the heavy cutting and the tunnel it now has to encounter. The delay thus occasioned to the branch need not, I think, necessarily prevent its opening as soon as the main line, should that now be carried.

I have the honour to be, Sir,

Your most obedient humble Servant,

R. ALDERSON.

Captain, Royal Engineers.

To the Inspector-General of Fortifications, &c.

Report on the several proposed Lines of Railway between London and Brighton. By Captain ALDERSON, *Royal Engineers.*

London, 27th June, 1837.

SIR,

IN obedience to your orders of the 2nd and 9th June, 1837, directing me to report, in conformity with the instructions contained in two letters received from Her Majesty's Principal Secretary of State for the Home Department, on the following proposed lines of railway between London and Brighton, viz. Sir J. Rennie's, or the direct line; Mr. Stephenson's, Mr. Gibbs's, and the South Eastern—

I have the honour to state, that I have carefully read over the evidence given before the Committee, as well as their report, and attentively compared the several plans and sections submitted to me; that I have also taken a general survey of the sites of the different lines, examining more attentively those portions where works of importance are proposed, and have no hesitation in stating, that the line proposed by Mr. Stephenson, considered in an engineering point of view alone, is preferable to either of the others.

Availing himself of the vallies of the rivers Mole and Adur, he avoids the heavy cuttings necessarily consequent on forcing a passage through the chalk ridges, known as the North and South Downs; and, with the exception of two short tunnels, one at Epsom and the other at Dorking, arrives at Brighton, *viâ* Shoreham, having only such ordinary difficulties to contend against as are necessarily consequent on undertakings of a similar nature and extent.

As, however, this is but one point for consideration of a main line of railroad, I will now proceed to consider the respective merits of the several lines, with reference to the second resolution of the House of Commons.

On referring to the map and the population returns, it will be seen, that the country passed through, or approached by either of the lines, as well as that on the coast, within reach of railroad communication by branches, containing neither manufacturing nor mineral districts, the towns present only the usual traffic of an agricultural population, and are, as compared with Brighton, of minor importance.

It appears to me, therefore, that after attending to one principal point in the construction of any main line, viz. that its London terminus be central; that route between London and Brighton which best unites engineering facilities with convenient termini should be preferred.

I will then consider the termini of the various lines with reference to the accommodation they afford to the metropolis at one end, and the town of Brighton at the other.

Each of the proposed lines avails itself of a terminus already constructed, or for which an Act of the Legislature has been obtained. Mr. Stephenson adopts the terminus of the London and Southampton Railway at Nine Elms, a little above Vauxhall-bridge, with a depôt on the banks of the Thames, branching from this line at Wimbledon-common, 5½ miles from the terminus.

The Direct line and Gibbs's adopt the Greenwich Railway terminus at London-bridge, and avail themselves of railway communication, already sanctioned and now constructing, as far as Croydon.

The South-Eastern has also its terminus at London-bridge, and, in addition to the Croydon, avails itself of 12 miles of the Dover Railroad, branching off at Oxted.

Taking the Middlesex side of the Blackfriars-bridge as a centre, and describing circles with the several radii of one, one and a half, and two miles, thus including within the last an area of upwards of 12 miles bearing the densest population in the world, it will be found, that, whilst the terminus of London-

bridge is within the smallest of these circles, that of Nine Elms is without the largest; under these circumstances it may fairly be inferred, that Stephenson's London terminus is not so conveniently situated as that of the other lines, particularly for an extensive passenger-traffic, as that of any line connecting Brighton with the metropolis is almost sure to prove.

The Greenwich Railroad being already constructed on a viaduct of sufficient width only for two lines of rails, I doubted whether it would be capable of affording sufficient accommodation for the increased traffic proposed to be thrown upon it, more particularly as on this line the trains start every quarter of an hour.

On inquiry, I found that the Greenwich Railway Company possessed sufficient ground, on each side, to enable them to widen the viaduct so as to meet any probable increase of traffic, and that a plan and estimate had been framed for this purpose, ready to be carried into effect as soon as required.

There is still, however, an objection of some importance to any new line adopting either this or the Southampton terminus,—the necessity of limiting the distance between its rails to that of the lines already laid down.

At Brighton, Stephenson's line, as in London, stops at the western extremity of the town, at Chalybeate-street: this is inconvenient for passengers; and besides, as one of the advantages proposed in connecting Shoreham with Brighton is, that the latter may obtain coal at a cheaper rate than at present, it is important that that article should be brought as far into the town as possible.

Gibbs's line, entering nearly at the same point as Stephenson's, extends its terminus further into the town, and is well situated with respect to Brighton.

The South Eastern, on the other hand, enters Brighton at the north-eastern part of the town, at Carlton Hill, and nearly as much to the eastward as Stephenson's is to the westward, and cannot, therefore, without great additional expense, get a branch to Shoreham.

This remark applies equally to Stephenson's and Gibbs's lines, with reference to the Lewes and Newhaven branches; and, lastly,

The Direct line enters at the north-western part of the town, having a depôt for goods abutting on Trafalgar-street, and a passenger terminus on Church-street, 35 feet above its level, to which an inclined plane, from Church-street, gives an access for carriages.

This appears to be the most central terminus of the four, and that which affords the greatest accommodation to the town of Brighton.

And here too, after alluding to the Brighton termini of the different lines, I must refer to the peculiar character of the property of that place; for I conceive that the second Resolution of the House of Commons, by opening the whole question, has rendered it necessary that I should do so.

This town owes its present importance to the proximity of the sea, at that place, to the metropolis, and large sums have been expended there for the accommodation of its numerous visitors; a railroad touching the coast before it reaches Brighton might transfer the advantage of position to another place, and sooner or later prove injurious to the property at Brighton, thereby causing a large capital to have been wasted without any corresponding national advantage; and in this point of view, Stephenson's and Gibbs's lines are both objectionable; not, however, to the extent they would have been had the situation of Shoreham with respect to the sea been better.

The termini of the lines having been considered, their relative facility of construction and subsequent expense of working must be noticed; and assuming for the present that the estimates given by the competing parties offer a fair comparison on the first head, the following Table will present at one view their respective merits in these different points. The two parts of the fourth column, showing the mean equivalent horizontal distances for each line, have been calcu lated from tables just published by P. Barlow, Esq.

Table showing the total Length of each Line of Railway between London and Brighton, the Portion to be constructed by each, the Estimated Expense, Equivalent Horizontal Distances, &c.

Lines.	Part adopted from other Lines.	Part to be constructed.	Total length of Main Line.	Horizontal Distances equivalent to Main Line.		Estimate for the part to be constructed, including one-tenth for contingencies and price of land.	Length of Railway to be constructed, including Shoreham.	Estimate.	Length of Railway to be constructed, including Lewes and Shoreham.	Estimate.	Length of Railway to be constructed, including Lewes, Shoreham, and Newhaven.	Estimate.
				Heavy trains, supposed 100 tons.	Light or passenger train, supposed 50 tons.							
	M. CH.					£		£		£		£
Direct Line...	9 3	41 59	50 62	61 5	56 11	897,073	47 47	983,725	55 54	1,098,107	61 42	1,199,906
Stephenson's..	5 30	49 66	55 16	60 72	57 77	974,016	49 66	974,016	—	—	—	—
Gibbs's	9 21	47 56½	56 77½	64 52½	59 23	1,040,834	47 56½	1,040,834	—	—	—	—
South Eastern,	20 0	32 12	52 12	62 28	57 73	949,955	—	—	41 40	1,171,018	—	—

N.B.—The Lewes and Shorcham branches are single lines of railroad.

It will appear from this table, that Stephenson's and the Direct line, in the heavy traffic, are nearly on a par, the former having the advantage by 13 chains only; that the South Eastern is next, and Gibbs's line the last; and that, in the passenger-traffic, the Direct line has the advantage of them all, the South Eastern, Stephenson's, and Gibbs's being the order in which the remainder follow, the South Eastern and Stephenson's appearing nearly equal.

It should also be borne in mind that, in comparing the Direct line with Stephenson's, about 2½ miles ought to be added to the length of the latter, to make his termini as central as those of the former. It must, however, be observed, that the equivalent horizontal distances are only a comparative measure of the time in which two lines can be passed over when the tractive power applied is on each line equal; the maximum velocity, as yet obtained, may be given to a train on a gradient of 20 feet in a mile, as well as on a gradient of 16 feet, by using larger engines: this would, however, occasion additional expense; but it is necessary that it should be remembered, since it shows the advantage of reducing the actual distance, when passenger-trains are to be very much considered.

The Direct line gives branches to Lewes, Shoreham, and Newhaven, the two latter being extremely valuable to Brighton, by placing it between two ports, with a certain and rapid conveyance to each.

The Shoreham branch of the Direct line appears to me incomplete in not communicating with the wharfs, like that to Newhaven.

Stephenson's and Gibbs's lines give a communication with Shoreham, liable to the same objections as that of the Direct line, and in a greater degree, and altogether exclude Lewes and the port of Newhaven.

The South Eastern gives a communication with Lewes and Newhaven, but excludes Shoreham, and has therefore a corresponding disadvantage in this respect to Stephenson's.

Had this line, however, adopted the terminus of the Direct line in Brighton, with the addition of its branch to Shoreham, and been able to select a better route from Oxted, it would, from having the smaller quantity of railroad to construct, have been the most desirable.

On the other hand, had Stephenson's line more central termini, and instead of making the coast at Shoreham, proceeded direct to Brighton, it would have had strong claims to consideration, and, if there were no lines already constructed south from London, deserve a preference over all the others.

Gibbs's line appears to unite the principal objection to the Direct line, viz.

the extensive cutting at Merstham, with that of Stephenson's line in going round by Shoreham; and though it preserves a better gradient than the Direct line, yet from its circuitous route works to less advantage than any of the others.

Taking then into consideration the great advantages of the termini of the Direct line; that it affords by its branches greater facilities of approach to the other towns on the coast within reasonable distance, avoiding unnecessary intersection of the country; and that it is on the whole the best working line, with the least length of railroad to support; (for, though the South Eastern has less to construct, yet each must support, in proportion to its traffic, whatever length of line it travels over;) and also, that the Croydon Railway offers greater advantages than the Southampton Railway in the construction of a main southern trunk line; it only remains to be seen what are the difficulties of construction it has to contend with, and whether they are such as can be recommended to be undertaken, to ensure between London and Brighton a line possessing the advantages which it would appear this does over its competitors.

On referring to the section, there appear to be three summits to be crossed viz. Merstham, Balcombe, and Clayton.

The former of these, the greatest work on the line, consists of a cutting through chalk of more than three miles in length, varying from 50 to upwards of 100 feet in depth, and which it is proposed to open out with slopes of one-sixth.

As the prejudice against tunnelling is rapidly giving way, I should imagine that this mode would be resorted to on a considerable portion of this extensive excavation, as it appears to me to be beyond the point at which open cutting is more advantageous than tunnelling, especially in so favourable a soil.

The greater part of the chalk obtained from this cutting must be run out on the adjoining land, not being required for embankment.

The next excavation of importance is at Handcross Hill, near Balcombe, at the 23rd mile, where a tunnel of 470 yards in length is proposed through favourable soil; and the 3rd at Clayton Hill, at the 36th mile, where a tunnel of 800 yards is proposed; both of which, I think, may with advantage be increased in length, for the reason previously stated.*

* In consequence of this recommendation, on the Report being referred to the Committee of the House of Commons, the following alterations were made:

A tunnel of 1320 yards was adopted at Merstham; the length of the tunnel at Balcombe was increased from 470 to 880 yards, and the tunnel at Clayton Hill from 850 to 1700 yards.

Lengthening the tunnel has also enabled the line to be altered, either within the parliamentary

At the southern extremity of the latter tunnel there is a considerable length of open cutting; the whole of Clayton Hill is, like Merstham, a chalk formation.

Of the embankments on the line, one at the 13th mile, one across the river and valley of the Ouse at the 26th, and those between the 30th and 35th miles, are the principal; but of this description of work, the most objectionable in the construction of railroads, though there is less than of excavation, yet there are many short deep vallies to be crossed by embankment, and which, owing to the excavations being concentrated in two or three places, instead of being spread over the line, must be formed from side cuttings.

After getting through Clayton Hill, the line runs nearly parallel to, and to the westward of, the turnpike-road to Brighton, to its terminus in Church-street, on a viaduct from its depôt in Trafalgar-street.

It will then appear, though the embankments are extensive, that on this line the amount of excavation through chalk forms the principal item of expense; and, from the conflicting evidence given before the Committee of the House of Commons, for the Direct and Gibbs's line, relative to the properties of chalk, and the best mode of excavating through it, and on which the correctness of the estimate for the former in a great measure depends, I thought it necessary to inspect, with great attention, the quarries at Merstham and Clayton, as well as one near Lewes, which is as deep as any of the proposed cuttings, and which has not been worked for ten years.

In none of these quarries could I see any thing to induce me to adopt the plan proposed by the Direct line at Merstham and Clayton, viz. vertical cutting, or with a slope of one-sixth; on the contrary, I was convinced that, in excavations

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distance, (100 yards on each side) or, with the consent of the landowners, where the deviation exceeded those limits, so as to pass over higher but steeper parts of the ridges, which in open cutting was unadvisable; and the amount of cutting has been thereby much reduced, particularly at Merstham and Balcombe.

The Dover Railroad Company also, as was anticipated, have applied to Parliament for leave to abandon their present line through the North Downs near Oxted, and continue under the hill to join the Brighton line at Merstham Mill, by which they avoid upwards of 2½ miles of tunnelling and some extensive cutting, thus giving to this line the whole of the Dover traffic on a quarter of its length; and affording an additional proof of the advantages of the Direct line with reference to the instructions contained in the Address of the House of Commons of the 8th of June last, on which the Report was framed, viz. "to keep in view the formation of one main southern Trunk line out of London, by which the unnecessary intersection of the country may be avoided."

through every description of chalk, more or less of debris would be found to accumulate, even were the sides not subjected, as in the present instance they would be, to a constant vibratory motion from the traffic, in addition to the action of the wet and frost; and that, in order to afford security to the public, tunnelling, or, if open cutting, benching, or slopes of one to one, as proposed by Mr. Gibbs, ought to be resorted to.

In comparing these objections in an engineering point of view, with the advantages the Direct line possesses, I am of opinion the latter are not too dearly purchased, and that it is the best line between London and Brighton.

In giving this opinion, however, I beg distinctly to state, that I do not pledge myself to the estimate; I think in all probability it would be found inadequate.

I may be permitted to remark with respect to estimates generally, that were they fairly and impartially framed, which experience has shown is not the case at present, they would, with other information arranged in a tabular form, something similar to that adopted in this Report, enable even unprofessional men, with the assistance of a good map, to decide between two or more proposed methods of obtaining the same object.

Having proceeded thus far, prior to receiving the plan of a joint line agreed to by the committee of the four Brighton Railway Companies, I shall now, in obedience to your orders of the 22nd instant, proceed to report on it, in conformity with the instructions received from Her Majesty's Principal Secretary of State for the Home Department.

It is proposed in this joint line that there should be two termini in London, one at London-bridge, and the other at Nine Elms, near Vauxhall; also two lines going south, one through the valley of the Mole, and the other through the Merstham Pass, meeting at or near Capel; and from thence there should be one line to Brighton, *via* Shoreham, adopting at Brighton the terminus and branches of the Direct line.

It is thus intended to construct between London and Brighton nearly 70 miles of railroad, independent also of using upwards of 14 miles of railway already constructed, and this too through a country possessing neither manufactories nor minerals, and with no town on the line, excepting Croydon, of more than 5000 inhabitants; and which therefore must principally look for support from the towns of its termini, only about 50 miles apart.

In the present uncertain state of the return which railways will make for the capital expended, and the absence of any great national advantages proposed to

be obtained, I cannot think it advisable to venture on so great an outlay of capital, or that the traffic is such between London and Brighton as to demand it.

The company proposing therefore, as a part of their plan, to come from Croydon, through the Merstham Pass, to Earl's Wood Common, the distance from thence to Brighton (29 miles) by the Direct line is all that is required to be constructed, to render the communication complete between the two great termini; whereas, in the proposed joint line, nearly 70 instead of about 42 miles of railroad will have to be constructed and maintained, as well as a second terminus and depôt, without any additional traffic, except what may be afforded by the towns on the line.

Under these circumstances, it appears to me that continuing the route proposed by the Direct line, from Earl's Wood Common to Brighton, is better for the interests of the company, and affords to the public all the accommodation required.

I therefore adhere to the opinion already given in favour of the Direct line.

I have the honour to be, Sir,

Your most obedient humble Servant,

(Signed) ROBERT ALDERSON,

Captain, Royal Engineers.

XI.—*Rideau Dams. By Lieutenant* Denison, *Royal Engineers.*

Lieutenant Frome having given an account of the causes which led to the construction of the Rideau Canal, and a general description of the mode in which it is converted into a steam-boat navigation, a more detailed account of some of the works by which this object is attained will probably be acceptable. The following description of the Hog's-Back Dam is drawn up from notes and memoranda taken on the spot during the progress of the work. Of the dam at Jones's Falls, I cannot pretend to give so detailed an account, but can only describe generally the manner in which the work was executed; but with the assistance of the accompanying plan, which has been furnished by Lieutenant Burgmann, I trust I shall make the explanation sufficiently clear.

The Hog's-Back Rapid, at the head of which it was proposed to construct the dam, the subject of the present paper, is formed by a ridge of limestone, which crosses the river Rideau obliquely, at a point about five miles above its mouth. On the right bank, which rises nearly vertically from the river to the height of about thirty feet, the limestone, which at that point is very irregular in its stratification, is but thinly covered with a bed of earth and gravel: beyond the immediate bank, the ground rises rapidly to the height of fifty or sixty feet above the bed of the river, and then continues more gradually to rise for 200 or 300 yards, to a rocky ridge, from whence most of the stone for the works in the immediate neighbourhood was procured. On the left bank the rock does not rise above ten or twelve feet above the bed of the river, and is covered with a thick bed of clay, which forms a steep bank rising about fifty feet above the bed of the river. In this bank two locks were placed, (one of which was a guard-lock) which raised the canal 117 feet 6 inches above the level of the Ottawa, this level being requisite to enable boats to enter the lock at the Black Rapids, a point on the Rideau about three miles above the Hog's Back. It being necessary therefore to preserve this level, two modes of accomplishing it presented themselves, viz. either by continuing the excavation through the clay bank of the river for the whole distance, or by constructing a dam across the river, and raising the water to the necessary height; and as the former of these two plans would have been enormously expensive, on account of the heavy cutting, and the numerous embankments that various small streams and gullies which fall into the river between the Hog's Back and the Black Rapids would have required, it was determined to adopt the latter expedient, and construct the dam at the head of the Hog's-Back Rapid, although the water at that point required to be raised forty-five feet.

The river just below the dam is about 170 feet wide, and in ordinary seasons, according to a rough calculation made on the spot, discharges about 170,000 cubic feet of water in a minute.

The specification for the dam stated, that the up-stream part was to be composed of earth, gravel, &c.; that the down-stream portion should be built of arched key-work, or as a dry wall made of stones laid on edge, and wedged together in the form of an arch; and that between these two should be twenty feet of good clay puddle, sunk two feet into the bed of the river. (See *figs.* 1 and 2.) The dam to be coped with stone at top, so as to allow the water to flow over it, and act as a waste-weir.*

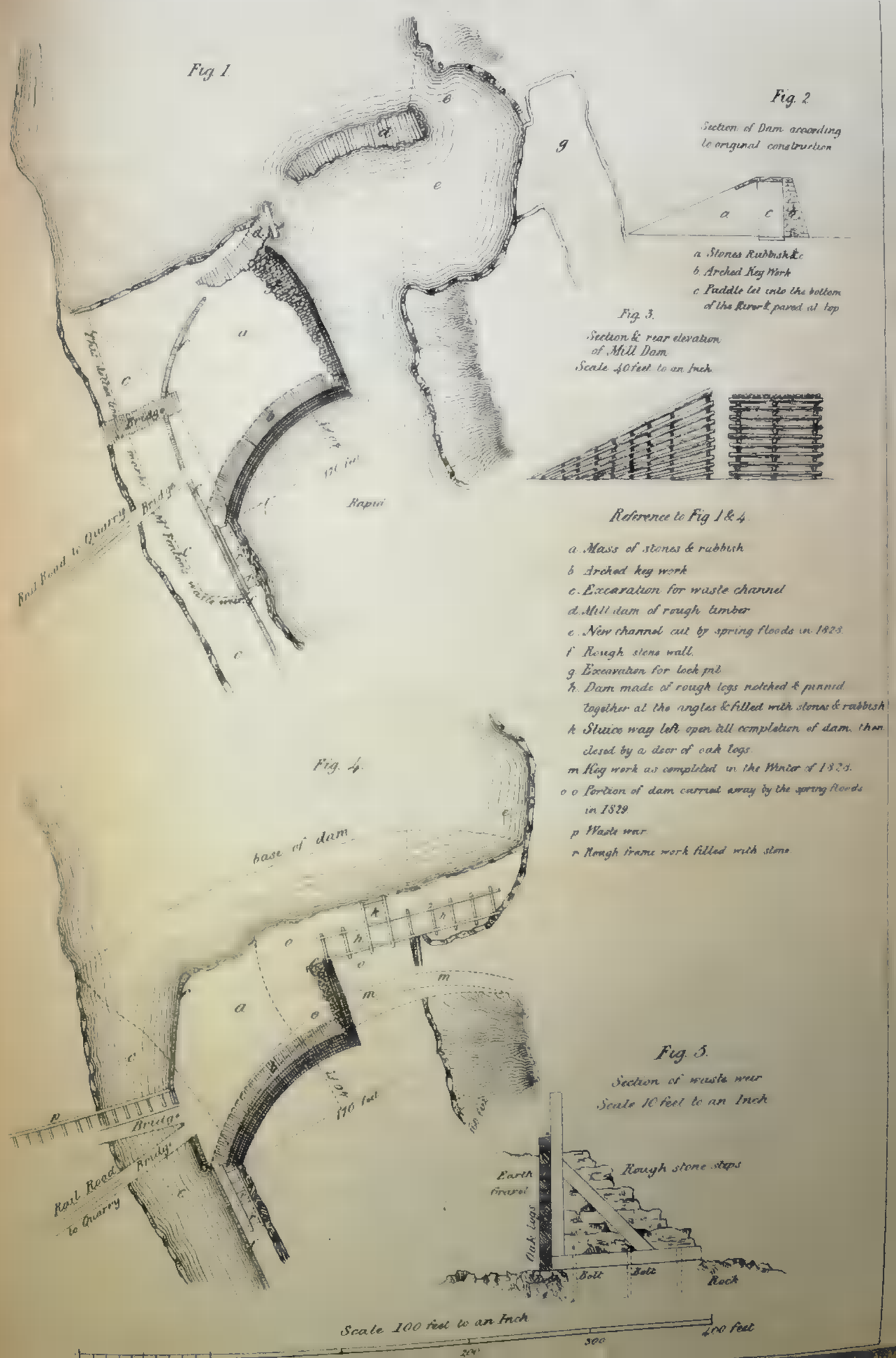
The plans, sections, and specifications for the work being published, various tenders were made for its execution. The contract was taken by a Mr. Fenlon, at the price of 1*s.* 10*d.* per cubic yard. The original estimate for the dam amounted to 10,808*l.* 16*s.*, while at this price the cost would only have been 4594*l.* 0*s.* 8*d.*

Mr. Fenlon having made what he conceived to be the necessary preparations for the work, commenced his operations on the right bank of the river, in the summer of 1827, as soon as the spring-floods had subsided. He threw stones, earth, and rubbish into the bed of the river, so as to form a sort of jettèe, by which the channel was contracted to about half of its original width, and behind this mass he built his key-work to the height of thirty-seven feet. Having accomplished so much of his plan, he attempted in the autumn to close up the unfinished portion. He cut a small channel through the rock on the right bank of the river, close to the flank of the dam; the bottom of this channel was about

* This was the general section adopted throughout; modified, of course, as to dimensions, according to the height the water had to be raised. In some instances the water was allowed to flow over the dam, but it was found that by so doing, if the fall was more than six or eight feet, the stability of the work was endangered, the puddle washed away, and such risks incurred, that in most cases waste-weirs were constructed, which carried off all the water in dry seasons, and by far the greatest proportion during the season of floods.

twenty-seven feet above the bed of the river, and its purpose was to serve as a water-weir to carry off the water when raised to that height. (See *fig.* 1.) Having taken this precaution, he attempted to close the opening by throwing in stones, rubbish, &c. and had succeeded in raising the water nearly high enough to flow through his waste-weir, when a sudden flood in the river swept away all the unfinished portion of his work, leaving it in much the same state as it was in the summer, before the attempt to complete it had been made. This happened in February 1828; and Mr. Fenlon having in consequence given up his contract, it became necessary to take some steps to provide against the effects of the spring-floods, either by securing that portion of the dam already finished, or by attempting to complete the whole, at all events to such a height as would turn the water down the waste channel. The former would probably have proved the safest plan, seeing the very short time which elapsed before the commencement of the spring floods; however it was thought advisable to attempt to turn the water. Accordingly the waste channel was widened and deepened, and its course altered, so as to afford a freer passage to the water. A rough wooden dam (see *figs.* 1 and 3) was erected before the unfinished portion of the work, one end of which rested on the portion of the dam already completed, and the other on the clay bank at the opposite side of the river. Various difficulties occurred in the construction of the dam, partly owing to defects in the plan, but principally to the state of the weather, the rottenness of the ice, increase of water in the river, &c. The dam was constructed of the largest timber which could be procured in the neighbourhood, principally pine and hemlock, from fifty to sixty feet long; but nevertheless the top could not be raised more than two feet above the level of the bottom of the sluice-way, which had been lowered four feet, and made nearly forty feet wide. Every precaution was taken to secure the flanks of the wooden dam, where it joined the clay bank and the old dam, but all these proved unavailing; the water rose very rapidly, overtopped the structure, (which gave way, and sunk partially in several places,) worked its way round the flank which abutted in the clay bank, and cut for itself a fresh channel: at the same time the additional pressure thrown upon the finished portion of the work did a good deal of injury, though nothing that did not admit of repair. This took place on the 1st of April, 1828. *Fig.* 1 shows the state to which the dam was reduced by the floods of that season.

In the summer, a Mr. Wright undertook, for the sum of 300*l.* to close the gap in the dam, and turn the water down the waste channel, which was enlarged



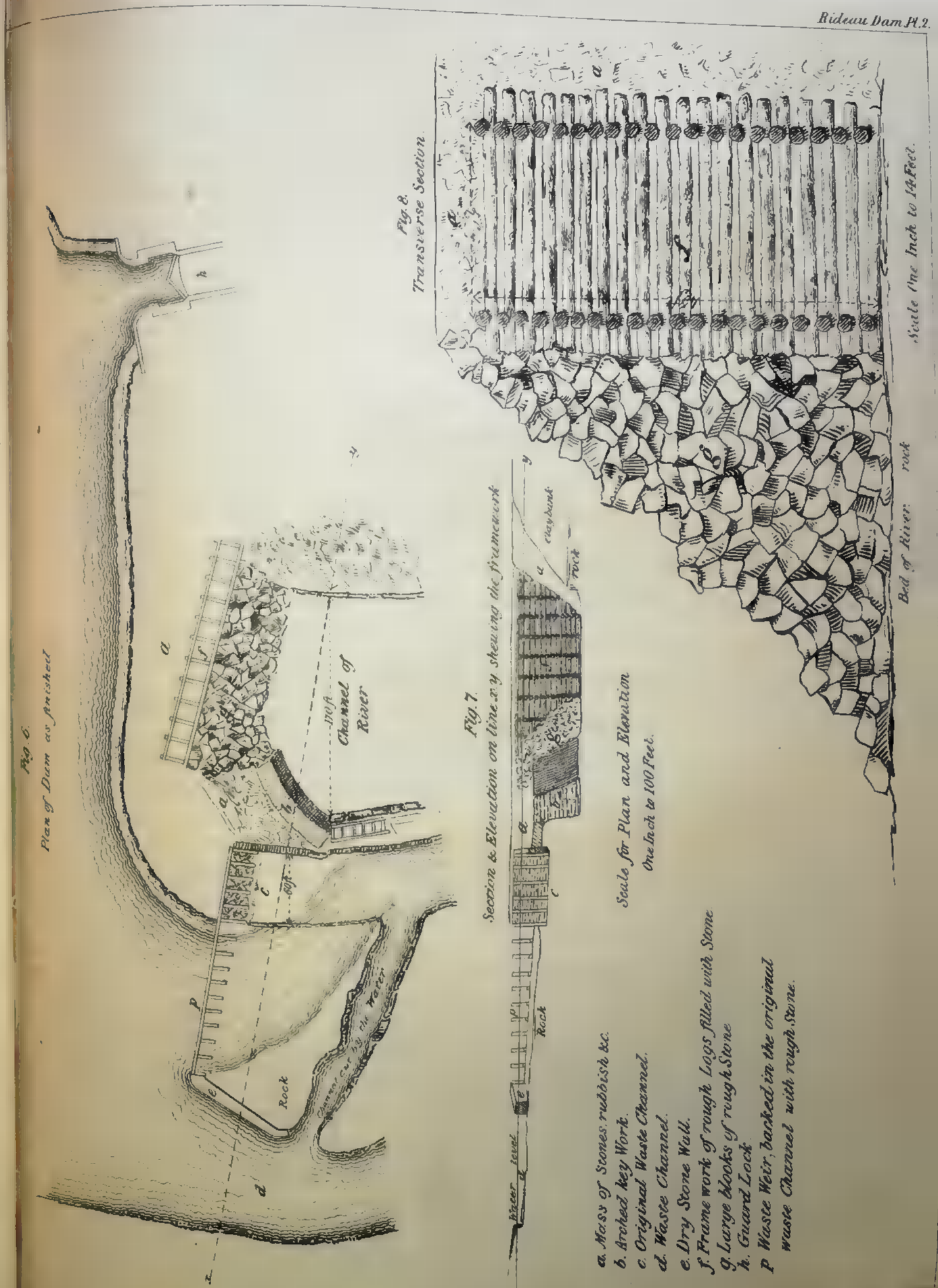
to the width of sixty feet. Mr. Wright accomplished his work in November 1829, by fixing a sort of coffer-dam, or caisson, made of rough timber notched together, and pinned at the angles, across the opening of the dam. This coffer-dam had a sluice-way twelve feet wide in the centre, which was kept open until the remainder of the dam was loaded with rough stone and rubbish, and filled in, in front, with clay: a door made of strong oak logs was then dropped down to close the opening, and clay and rubbish thrown in front till the water was completely stopped, after which it rose rapidly, and discharged itself through the waste channel. Two partial breaches in Mr. Wright's work were easily repaired, by driving sheeting piles across the openings made by the water. As soon as the water was turned through the waste channel, the key-work was commenced in the rear, and both Mr. Wright's work, and the portion of the dam constructed by Mr. Fenlon, were thickened and heightened: the earth too on the rocky bank on the right of the river was cleared away, so as to allow as free a passage as possible to the spring floods. All this work was carried on during the winter: the frost was so intense, that powder was used to procure the earth necessary to fill-in the front of the key-work, which was raised to the height of thirty-seven feet by the middle of March 1830. The earth and clay in front of it was raised to the height of fifty feet, but to puddle was impossible, on account of the severity of the weather. At the same time that these works were carrying on, the waste channel was stopped, and the water turned over the rocky bank to the right of it. Before the water was raised, oak sills had been strongly bolted down to the floor of the waste channel, with mortises to receive uprights, and braces to support them in rear. These were now fixed, and in front of the uprights squared oak logs were laid, and pinned as well as possible to each other, and to the uprights. This kind of work was continued beyond the waste channel for a distance of 130 feet upon the right bank; and by driving down oak plank where the inequalities of the rock permitted the water to escape, and filling-in in front with clay and gravel, the surface of the river was raised about fifteen feet higher than the bottom of the waste channel, and the width of the water-way increased to about 150 feet. Up to the end of March every thing appeared safe, the main body of the dam was nearly water-tight, and showed no appearance of a settlement; but on the 1st of April the water in the river began to rise; on the 2nd, a large portion of the earth in the centre of the dam settled down, allowing the water to act upon the key-work, through which it flowed, carrying with it large quantities of the clay, of which the front part of the dam was principally composed. All

attempts to lower the head of water, by clearing away the waste channel, or to check the rush of water through the dam, by throwing in brushwood, &c. proved abortive; and on the 3rd the stone key-work gave way with a tremendous crash, the whole body of water discharged itself through the opening thus made, carrying with it the most part of the winter's work, and leaving a gap of about ninety feet in width in the dam. A portion of the wooden frame-work constructed by Mr. Wright withstood the torrent, which in consequence acted more powerfully upon the old portion of the dam, and carried away a great portion of it.

The enormous power of the frost in Canada was exemplified in an extraordinary way during this catastrophe: the whole mass of earth above the level of the water remaining suspended for about five minutes after the key-work had given way, forming an arch of at least fifty-feet span, under which the river roared and foamed, and over which several people passed safely; in a short time, however, the action of the water widening the breach, carried away the abutments of this arch, and the whole was precipitated into the river.

In the summer, after the spring-floods had subsided, and the amount of damage been ascertained, it was decided to continue Mr. Wright's wood-work across the opening, to raise it higher than he had done, filling in every bay with broken stone or gravel, and backing it in rear with heavy blocks of stone thrown from the top, and allowed to take their own slope. All idea of completing the dam with key-work, according to the original plan, was given up; the costly experiment of the winter having proved the impossibility of wedging rough stone, of the description to be procured on the spot, into such a compact form as to enable it to resist the pressure, which any failure in the mass of materials in front would bring upon it.

The work was commenced in July, and carried on very rapidly. The frame-work was easily raised after the first course of timber had been laid across the bottom of the river, and this did not present the difficulties which might have been anticipated. A strong log of timber was laid parallel and close to the bank of the river; on this were notched, at about twenty feet apart, two rough timbers, about fifty or sixty feet in length, which were supported against the stream by guy-ropes; under these, at intervals of fifteen or twenty feet, other logs, parallel to the first, were inserted, and as soon as each bay was completed, it was loaded with stone, which enabled it to resist the action of the water; other timbers were then pushed out upon these, and supported in the same manner, and the work was carried on in this way till the opposite bank was reached; a second course



of transverse and longitudinal timbers was then placed exactly over the former, and the work being now able to resist the effect of the water, no more stone was thrown in, the water finding its way freely through the openings between the timbers. As soon as the frame-work was raised to the proper height, a roadway was formed along the top, and the bays at the two extremities were filled with small stone and gravel (see *fig.* 4); at the same time large blocks were thrown over at the rear, and clay and gravel filled in at the front. The work was thus carried on from the flanks of the dam to the centre, and a mass gradually formed, the base of which extended upwards of three hundred feet up the river.

While this was executing, the waste channel was widened nearly one hundred feet, by clearing away the earth down to the rock (*fig.* 6 and 7), a rough wall (*e fig.* 6) built to throw the water from the flank of the dam, rough stone steps laid behind the wooden frame-work of the waste-weir, to prevent the action of the water upon the rock to which the sills were bolted; in fact, every expedient which the skill of the officer in charge of the work could devise, or the means at his disposal enable him to execute, was put in practice to guarantee the work against accidents or failures. The water was raised, by the 30th November, high enough to flow over the waste-weir; and from that time, although partial settlements have taken place in the earthen portion of the dam, nothing has occurred which has in any way threatened its stability. The changes that have taken place below the dam (see *fig.* 5), are striking exemplifications of the force exerted by a large body of water in rapid motion;* the channel shown in *fig.* 6 was cut to

* The following account of the destruction of the foundation of one of the piers of the aqueduct at Rochester, over the Genessee river, will show that no precaution can be too great in situations when the work has to withstand the action of water in a stream whose violence is liable at times to be increased by heavy floods.

"In the autumn of the year 1821, one of the piers of this aqueduct had been laid from the foundation about two feet high. This work consisted of large stone, in courses about a foot thick, and each stone was fastened to the rock on which it rested by iron bolts, passing about one foot into the rock below, and secured by fox wedges. These stones were afterwards cramped together. The next spring no vestige of this work remained, except the iron bolts in the bottom, and these were bent down with the course of the stream, so as to present the least possible resistance to any substance put in motion, and carried down by the current. This pier was in the most rapid and exposed part of the channel, and possibly would have proved sufficient, if the work had been carried above the utmost rise of the waters; as it was, it served to impress us with greater views of the prodigious violence and power of the stream in time of floods, and this impression we have constantly carried with us in our subsequent labours. At the place from which our work had been removed, instead of commencing again on smooth and level rock, as had been the case in the first instance, we excavated an oblong square into the bottom, six inches deep, of the exact size required for the pier, and then placed a course of very large stones, which

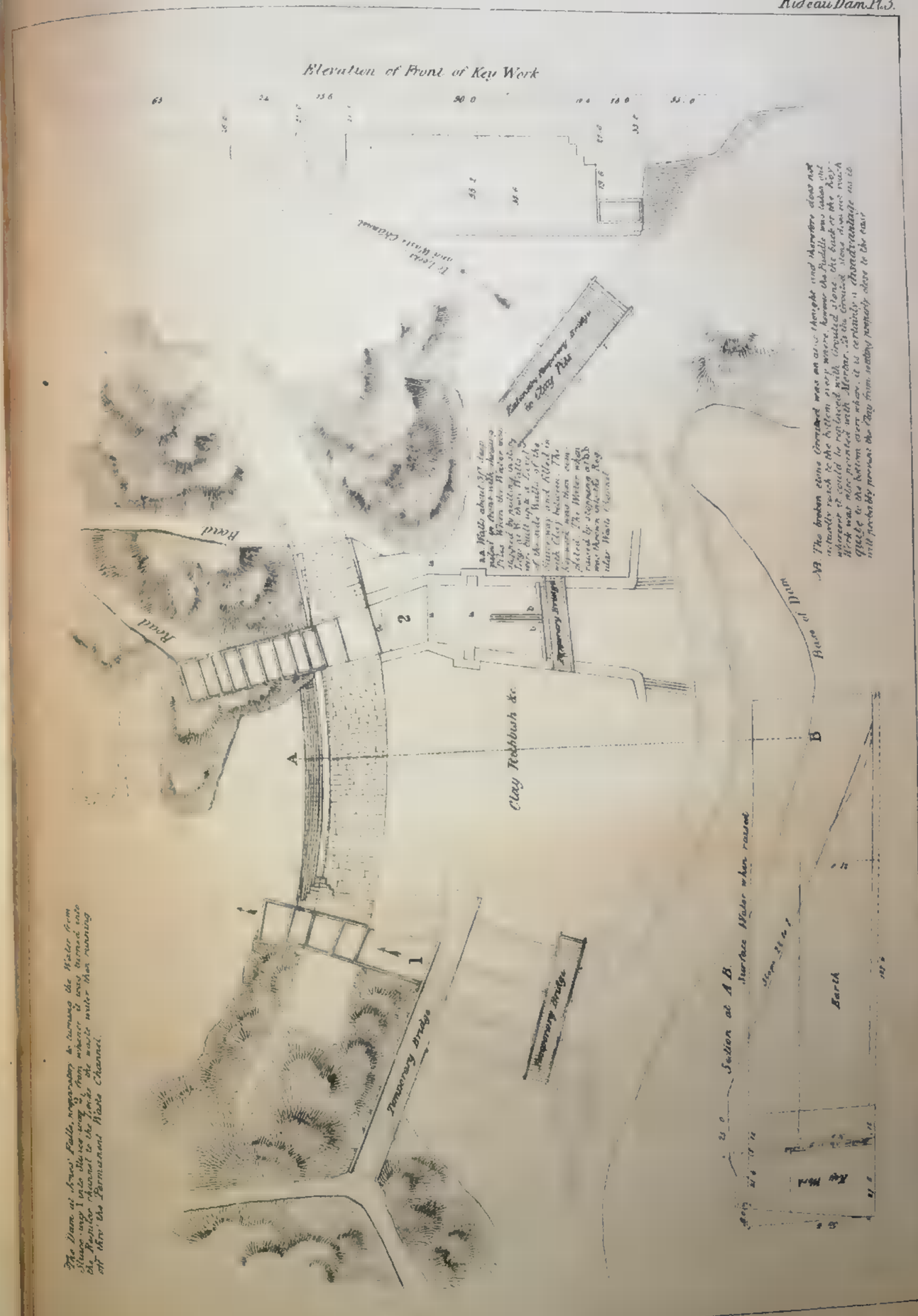
the depth of ten or twelve feet, in a very short time, through a mass of hard rock, irregularly stratified. A similar action is going on in other portions of the waste channel; and although there is no immediate prospect of the action of the water wearing away the rock, in such a manner as to reduce the head of water sustained by the dam, yet in a series of years this will probably be the case. In every attempt, therefore, to raise the level of the water of a river by means of dams, great attention must be paid to the outlet provided for the stream: the descent from one level to another should be on as gentle and regular a slope as possible; and if an abrupt pitch is unavoidable, it should be broken if possible into steps, in order to diminish the action of the water. This was done (see *fig.* 5) with good effect at the back of the wooden waste-weir at the Hog's Back, where, previous to that expedient, the action of the water, with a fall of six or seven feet, had worn away the stone from under the sills, leaving, in many places, the iron bolts exposed for a great portion of their length.

s's Falls n.

The works at Jones's Falls are situated in a narrow rocky ravine, with high banks, which serves as an outlet to the waters of Sand-Lake. In this ravine it was determined to erect a dam sixty-one feet high, according to the construction before described, in speaking of the Hog's-Back Dam, *i. e.* with stone key-work in rear, a mass of earth and rubbish in front, and clay puddle between the two. Some sand-stone quarries, not far distant, afforded stone of the best quality and the largest size; and the work was commenced by erecting a wooden temporary dam at the mouth of the gully, by which, when necessary, the outlet of the lake could be stopped, and the works kept free from water for about a week in the dry season, without any fear of raising the water in the lake so high as to do any mischief.

A temporary wooden sluice-way, marked A in the plan, was then constructed close to one side of the ravine, at the spot where the dam was to be constructed; and this being made of sufficient width and depth to carry off all the water that usually passed down the gully, the remainder of the pas-

were two and a half feet thick. These stones were secured to the rock by larger bolts than had been used before, and they were strongly connected together by large bars of iron, sunk into the stone, and extending round the pier on the top of the course, and then secured to each stone by several bolts. In addition to these means of strength, besides filling the work with water-proof grout, each end of the pier had a bar crossing it diagonally, and let in and bolted like those before mentioned, so that it is deemed impossible for the pier to be moved by water in pieces; it must remain stationary, or all be swept away at once. The next courses above consist also of very large stones, secured by bars and bolts, like the lower course.—(*New York Canals.*)



sage was blocked up with earth and rubbish, behind which the key-work was built to the height of about eighteen or twenty feet. At this height, on the opposite side of the dam, a fresh sluice-way was made, the part through the key-work being framed of wood, and the remainder of masonry; sheeting piles were driven in several places, to prevent the water working its way beneath the floor of this sluice, which was carefully planked. As soon as this sluice-way was completed, and the key-work and remainder of the dam raised some height above it, the outlet of the lake was stopped, and every exertion made to close the old sluice-way, filling in the opening with rubbish, and building the key-work behind. The water being then allowed to pass down the ravine, rose in front of the dam, and discharged itself by the second sluice-way. After this, the work went on as before, and a permanent waste-channel having been excavated in the rocky bank of the ravine, provided with sluices, and every thing requisite to regulate the height of water when this second temporary sluice-way was closed, the water was turned into this permanent channel, and the dam was then completed to the requisite height without any further trouble.

The annexed sketch shows the plan of the dam, and position of the temporary sluices; the rear elevation of the same, just previous to the closing of the first sluice; and a section of the dam as completed.

W. DENISON,
Lieutenant, Royal Engineers.

XII.—*A Memorandum of the Manner in which the several Repairs of the Chain-Pier at Brighton have been executed, together with some Reflections on its Construction and Durability.* *By Major* PIPER, *Royal Engineers.*

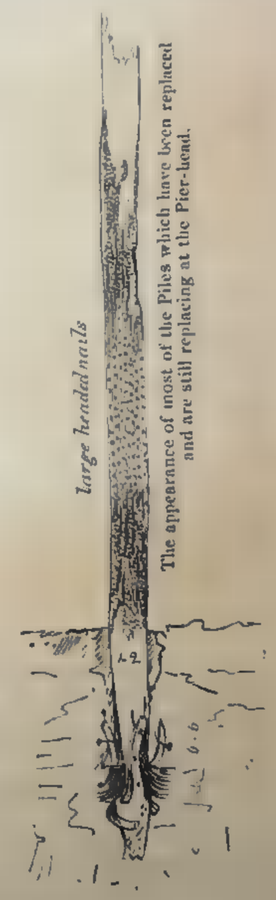
IN an account given by Lieutenant-Colonel Reid, relative to the failure of the Chain-pier at Brighton, on the morning of the 29th of November, 1836, he particularly noticed the degree of undulatory motion to which the whole line of roadway was subjected, immediately preceding its disruption; and, as that motion could only have been given to it by the pressure of the wind, (the waves not having reached the roadway,) the following observations have been committed to paper, with the hope of explaining what has since been done to obviate a similar accident; and, as particular attention appears to have been paid to this circumstance, during the restoration of the work, it is hoped the accompanying sketches may contribute to illustrate them.*

Fig. 1 is an elevation of the second bay or opening of the chain-pier as now completed, and shows the manner in which it has been strengthened. The several additions and amendments have imparted considerable strength and firmness to the whole line of roadway; they have been collected and arranged with as much exactness as casual observation, coupled with hasty admeasurements, could afford; and should they be thought worthy of notice, amongst other subjects connected with the duties of the Corps, (having been intended for private memoranda only,) their object will be answered.

The several openings of the pier being similar, (the distance from the centre

* The columns of the pier are severally 37 feet in length by 24 feet in width, and contain, exclusive of the buttress-piles, twenty piles each; they average from 38 to 40 feet, and are 14 inches square, and were intended to have been driven 8 feet 6 inches into the ground; but, from its extreme tenacity, they never could reach 7 feet. They are girt all round (about midway down, or 15 feet below the roadway,) with 12 inch walepieces, well bolted, and are further secured at their bases by coffers (*fig.* 1), laden with chalk. Those timbers, which are alternately wet and dry by the flow and ebb of the tide, continue sound; but those at the outer pier, which are always in the water, are fast deteriorating. The piles appear to be principally of beech and pine; but in some few cases recourse has been had to oak, and they are all shod with 1¼ cwt. iron shoes, having straps and points of wrought material, and kernels of cast-iron.

of one pier to the centre of its collateral one being 274 feet 6 inches, (c c and n, *fig.* 1,) and the versed sine of the curve of the chain 23 feet 6 inches,) the subsequent observations will apply to all, as the same description of work has been executed throughout. The buttress-piles of the outer piers, all bevel seaward, as represented by the dotted lines (p, *fig.* 1,) in the left-hand pier of the section, being drawn at a greater inclination than the rest in the diagram, for the purpose of enabling the piers to offer a firmer resistance to the continuous efforts of the sea, when distributing itself amongst the piles; and as the violence with which it breaks is very sensibly felt throughout the whole work, it would be liable, were they otherwise arranged, not only to loosen them in their foundations, but to throw them into winding: and this dangerous result therefore is, above all others, to be guarded against from the great height to which the piles rise above their bases, (their average lengths out of the ground being, at least, 38 feet,) together with the extreme weight they have to sustain* in carrying their respective platforms, towers, and chain-work; they would, if left unprotected, become unsteady and be incapable of retaining their upright positions, from which, independently of other incidental causes, by which the work has already suffered, it would in all probability be again destroyed.



The soil or bottom on which the piers have been erected is composed of compact chalk, interspersed with flints; and as each pile, in finding its way to its proper depth, tended originally to loosen it, it is presumed frequent trials, either to renew the timber or extract the old piles, would be attended with the same consequence; and as masses of chalk, amounting to several hundred weight, have, in some instances, during the latter operation, been returned to the surface, any attempt to reform the work would, it is thought, be attended with serious difficulty. The sea-worm and other

* The towers are said to average, each ..... 4½ tons.
Main-chains and iron-work of each bay ..... 15 „
Platform and roadway, ditto ..... 20½ „

marine insects, have commenced destroying the footings of the piles at the pier-head to some extent; considerable repairs will therefore be required from year to year, or the whole will, necessarily and speedily, go to ruin. As the expense of continuing these outlays with perishable material will no doubt, at a future time, form matter for consideration, it is more than probable an effort will be made to build it of stone.

Figures 1, 2, and 3. The part covering the centre-half of the platform of the span is a wooden segment, composed of seven pieces of 3-inch plank, scarfed and keyed, and bolted together, as in diagram No. 3; and is intended, in conjunction with a chain, to resist the tendency to undulatory motion in a vertical direction. The chord of its arc has been determined at one-half the distance between the main supports, or points of suspension, and its height at a sixtieth part of its length.

The chain which, as before-mentioned, is used in connection with the wooden segment, is led completely over the spine of the latter, by means of a hollow draft or groove (b, *fig.* 2), and being passed beneath the roadway, (A and b, *figs.* 1 & 3,) it is then extended from pier to pier, and there secured by flat $4\frac{1}{2} \times 1$ in. bars of iron, (b, *figs.* 4 & 7,) having their ends passed through the three adjoining piles, and counterwedged (b b & 2 b, *figs.* 1 & 4).

Fig. 2 is a cross section through the immediate centre of the main arch or opening, and represents the manner in which the binding-chains (b b b, *fig.* 3) are conveyed over the segments; the way in which the large chains are connected with the suspending-rods and platform, &c; and, finally, the manner in which the several (a i) parts, girders (o) and cast-iron caps, (n) and suspending-irons, straining-beams, (f) side-pieces (d) and transoms (B, *fig.* 1,) are placed in relation to each other; and the whole * together is a specimen of great simplicity and strength, and forms a very efficient communication with the shore.

* The Rods of the main-chains are of ..... 6 in. round iron.
Binding-chains ..... $1\frac{1}{8}$ ditto.
Suspending-irons ..... 1 ditto.
Girders ..... 4 in. 1 in. flat.
Balustrade-irons ..... 1 square bar.
The caps and bands are 30 lbs.

The transom-beams, side-pieces, and platforms, are all of 3-inch stuff; the straining timbers, 4×6, and the piles 14 inches square; and the rest of the material, whether walepieces or braces, 1 foot square.

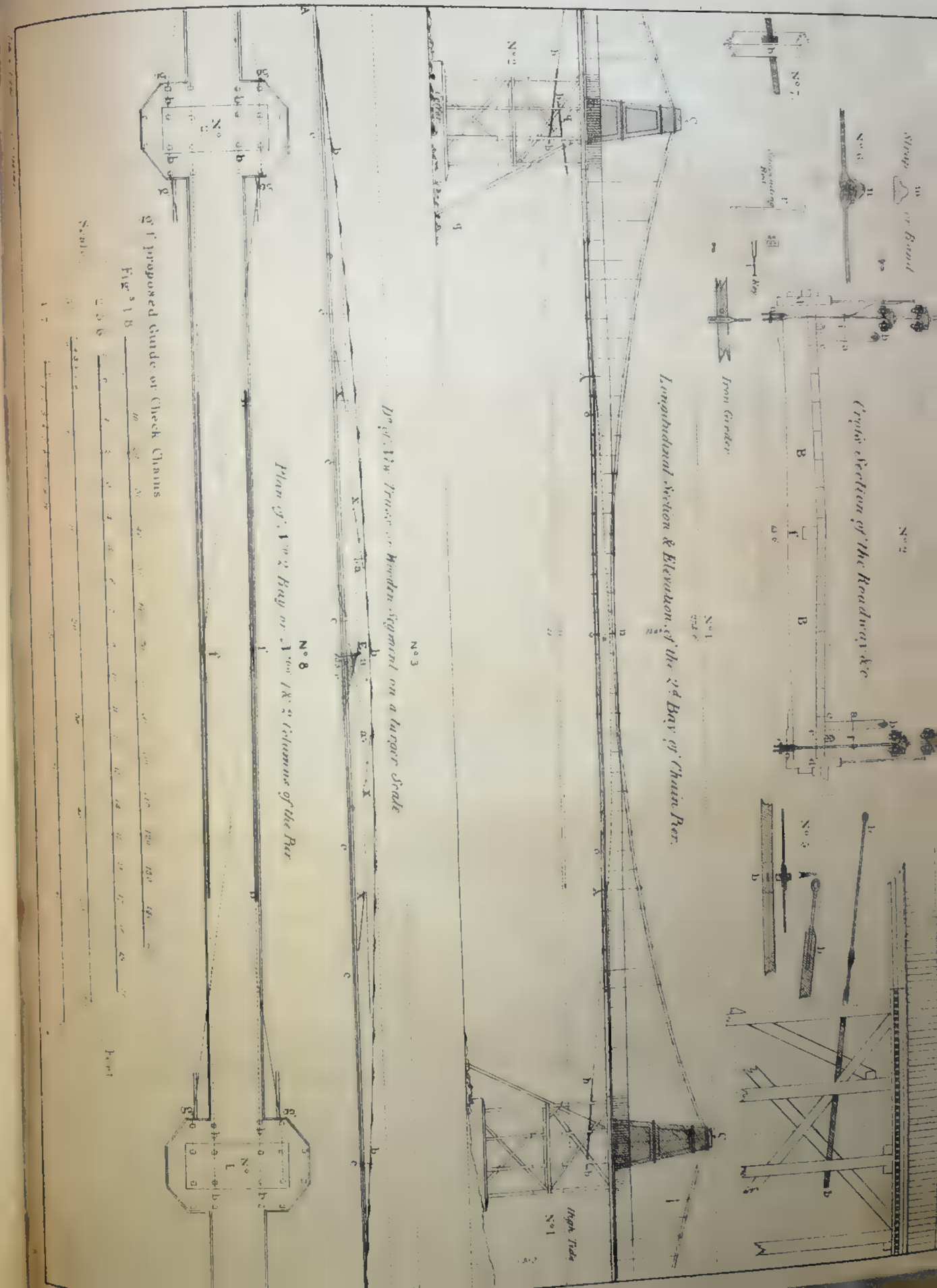


Fig. 3 is the wooden segment, on a larger scale, and represents the way in which the planking has been contrived and framed, as also the string-piece (e) or die to which it was afterwards added; when being keyed (x) and bolted (x) it was placed, as shown in the diagram, and bolted (c) through (c) to the planking of the roadway (c); only that it was omitted to state, that each piece, except the die, was ploughed and tongued, and put together with white-lead. The base, or chord of the segments, has already been said to be 135 feet, with a versed sine of only 2 feet 3 inches.

Figs. 4, 5, 6, and 7, are sections, or side-views of the upper part of No. 1 pier of the principal bay, and show the manner in which the ends (b) of the chains, or rods, are welded on to the binding bars; the method of connecting them in lengths (b), and the way in which they are keyed up (b, *fig.* 5) and secured at the backs of the piles; and, lest the manner in which this process is effected may not be clearly defined, a small part of a pile at the near pier has been added to the section, having a stout plate (b, *fig.* 7) of boiler-iron on its reverse, for the purpose of protecting it from the chafing of the counter-keys: and that No. 6 sketch may not be misunderstood, it is intended to represent a joint (n) in the principal chain at which the suspending rods (r) and cast-iron caps take their bearing, together with the newly applied hoop or band (m, *fig.* 6); and as there can be little doubt, if these severally retain their strength and positions, the superstructure has a much greater chance of security than it previously had, the band being so contrived as to compass the short links and ears of the cap together, without interfering with the play of the joint; which was not the case in the former failures, the caps being always thrust from off their seats, by the undulatory motion of the roadway: it is anticipated the precautions which have now been used will meet with success.

Fig. 8. The remarks on the repairs made to the pier have been extended to a much greater length than was at first intended; but it may be desirable, before closing them, to take notice of some few points which have not yet been attended to; and of these the most important is the effect to be anticipated from the lateral pressure of the wind on the side-elevations of the bays: this lateral strain (the vertical one being always consequent upon it) is the worst that can be received from the course of the wind; and as it appears to have heen a principal cause, if not the only one, of all the hazardous movements of the superstructure, should another equally severe gale of wind take place before other checks than those

which have been added be applied, it is very possible a repetition of the disaster will take place, against which every precaution should be taken. As a limit should be given to this description of dangerous motion (flexibility being necessary only to the extent of preserving the work from fracture by any sudden strain, from whatever direction), it seems therefore advisable, that every bridge or arch built upon the suspension principle, should be furnished with guide or check-chains, (gf, and fg, *fig.* 8,) to counteract the effect of the pressure of the wind in a lateral direction, which should there be applied, in addition to the chain intended, to check the motion in a vertical direction. It is imagined, that however severe the wind may hereafter prove, the superstructure would remain firm: but, as the effect of a heavy rolling sea in stormy weather might be productive of much damage, from curling up and breaking underneath the platform, which is often the case, it would add to the security of the communication if a few planks, on either side, in parallel courses, were to be hung on hinges, so as to admit of their being lifted, on a slight pressure from below; and this trifling alteration would afford a free channel to the water, and afford some guarantee against one of the greatest risks the roadway has to undergo; whereas, if an united effort of the sea and wind were to take place (it heretofore never having had to contend with both), it cannot be doubted but much injury would be sustained, and it would therefore be a matter of useful precaution to open out the planking of the roadway as suggested.*

* On the 17th October (present year,) the repairs having been completed, a heavy rolling (spring tide) sea,† impelled by a tremendous gale of wind from the westward, came pitching on to the shore with the flow, at the rate of nearly 16 knots; and as many of the waves, previous to their discharge, lifted to an average height of 13 feet over and above the usual high-water mark, breaking violently at intervals over the whole length of roadway, the binding chains and segments may be said not only to have had a fair trial, but to have answered their purpose; yet the constant tugging and pressure, from the effects of the wind, along the whole communication, was so great as to throw the section into a complete state of winding, giving it the appearance of being n distress; wherefore, if the pressure of the wind, in so unfavourable a direction, be taken into consideration, (supposing the same to be from the flow of the scud at a moderate calculation, about 4lb. the square foot, which it must have been,) a fair inference may be drawn as to what a

† The time between the rising, reach, and dispersion of each wave, was averaged by stop-watch at 10 seconds, and the distance passed over 250 feet, giving a velocity of 17 miles per hour. Desultory waves broke heavily and with effect at 15 and 16 feet, threatening to tear up the platforms of the towers; and had the wind shifted to the south of west, with the increased send which would then have been given to the swell, the scene of last year would most likely have been repeated.

As the foregoing remarks are applicable to any case where a work of suspension might be intended for a similar purpose to the one at Brighton, or for any other exposed situation, it is hoped they may be found interesting, and not extended to an unnecessary length.

Brighton, Nov. 1837.

work of this nature has to contend with; and as every season must also tend to weaken its foundation, as well as loosen the pile-work, it is evident accidents will happen, and it is only matter of surprise they have not occurred more frequently.

XIII.—*Further Observations on the Moving of the Shingle of the Beach along the Coast.** *By Lieut.-Colonel* Reid, *Royal Engineers.*

At page 44 of the first volume of 'Professional Memoranda,' there is the following statement, which refers to the south coast of England:—"The prevailing winds being westerly, and the highest seas rolling from the south-west, the pebbles of the beach are gradually carried to the eastward, and a constant supply is furnished by the falling away of the cliffs. On this coast, therefore, groins so constructed as to prevent the moving shingle from pressing to the eastward, cause an accumulation of pebbles."

Dorset coast. Lyme Regis.

It has been ascertained, since last year, that the pebbles of the Devonshire coast are forced to the eastward, along the coast of Dorsetshire, as far as the Chesil Bank. The stone-pier of Lyme Regis, called the Cobb, does not, as might have been expected, arrest their progress; for, in south-west storms, they are driven over the pier, and the crews in the harbour have had to quit the decks of their vessels, on account of the stones driven over the pier falling on the men. On this account, within a few years, a high wall has been constructed to stop the progress of the shingle at this point. The natural consequence to be expected

* The observations on the effect of the waves in this paper apply to breakers on the coast, and not to undulations in deep water, for the water in them is said to have no progressive movement, but only a vertical one.

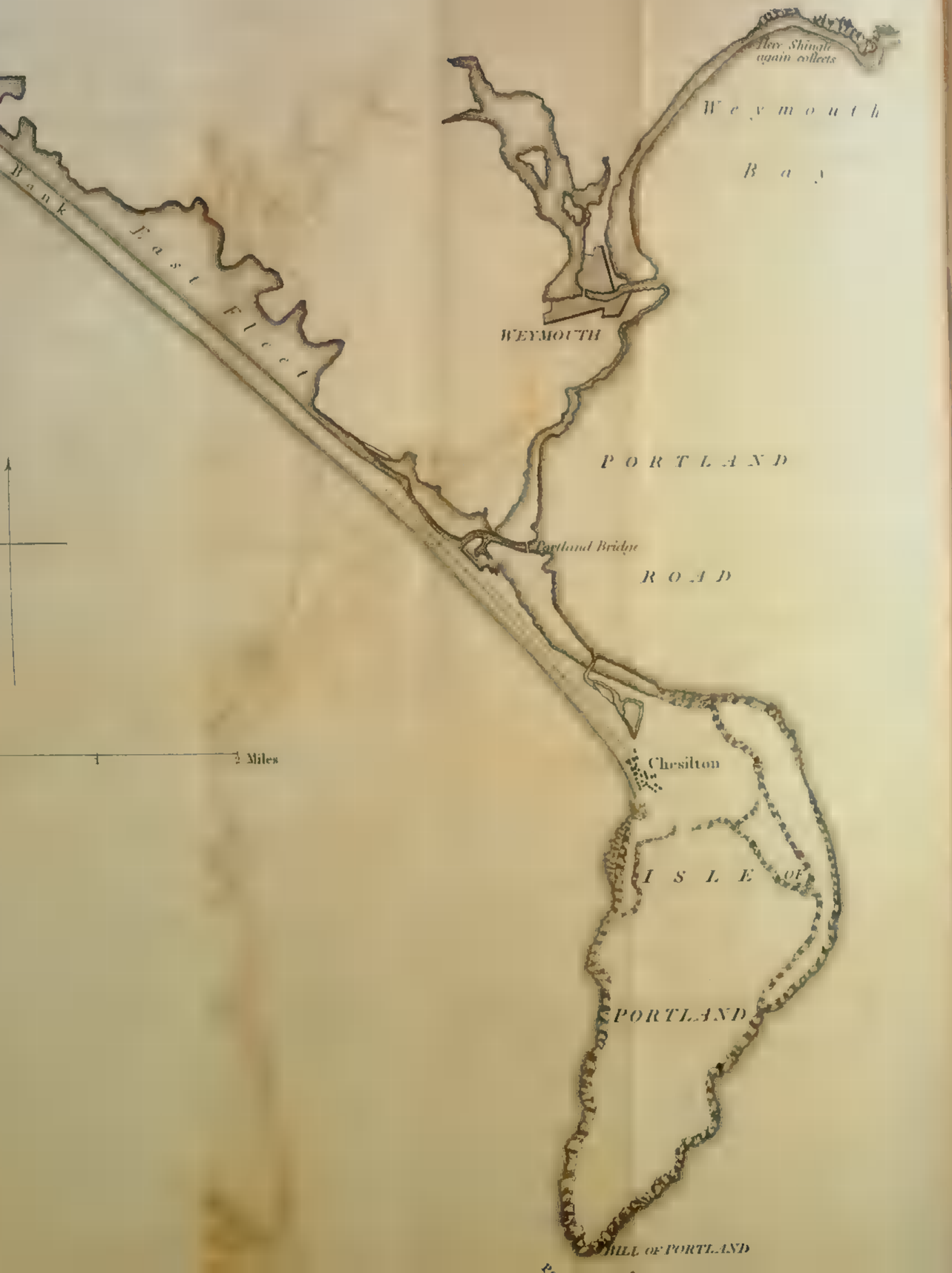
In ordinary gales of wind at Brighton, in the winter of 1836, the undulations of the waves measured twelve feet high; and they proceeded towards the shore at the rate of twelve miles an hour.

In the winter of 1837, Captain Alderson observed them, in gales rather more severe than the year before; and the waves measured 12½ feet high, and the undulations proceeded at the rate of eighteen miles an hour.

The length of the chain-pier being known, and a graduated pile standing at the further end, these observations may be verified during any heavy gale.

Dr. Wollaston, who measured the velocity of waves from a Leith smack, at anchor on the east coast of England, made the rate of progression sixty miles per hour, which must have been an error.

The velocity was measured in the Chinese seas, at the request of Horsburgh, the late hydrographer to the East India Company: the result was, a belief that the rate was sixteen miles per hour, when a ship was going eight knots; and this nearly agrees with the observations at the Brighton Chain-pier.—*Horsburg, E. I. Directory*, vol. ii. p. 11.



from this wall is, that the shingle will accumulate on the west side of Lyme Regis pier, until it shall roll round the pier-head, as at the harbour of Dover. Dover.

The Chesil Bank is not composed of calcareous pebbles,* (as stated in a work of deservedly very high reputation) but mostly consists of silicious stones, worn to a very remarkable degree of uniformity of shape and also of size, (when taken from the same point) by long attrition upon the coast. The largest pebbles have been carried furthest to the east; and the regularity with which they are arranged, according to their sizes, is very remarkable. Chesil Bank.

The progress of the shingle is here first arrested by the Isle of Portland, owing to the projection of that point of land in a line somewhat to the westward of south, and the shingle bank stops just where the land trends in a south-west direction. Portland acts as a groin.

The Chesil Bank, at that part of it nearest the Isle of Portland, is from 20 to 30 feet above the ordinary high water-mark. On the west side it is steep, and the water deep close to the shore; but on the east side it has a gentle slope, with a base of 200 yards, to the above height of 20 or 30 feet.

This gentle slope on the east side is owing to the accumulation of water on the opposite side during westerly gales, which finds a passage through the gravel bank, washing it into little ravines, and carrying down stones by its current. In very severe storms the sea washes over this bank; and it did so on the 23rd of November, 1824.†

A dangerous shoal of coarse sand, called the Shambles, which lies off the south-east point of the Isle of Portland, is in all probability formed by the tides; but the Chesil Bank is formed by the waves breaking on the shore in south-west gales: and it is important that these two causes, and their resulting consequences, should always be separately considered. Action of tides and waves different.

Silicious or very hard pebbles only withstand long rolling on the beach; whilst calcareous stones soon become ground into sand. As the silicious pebbles do not pass round Portland Island, sand only is found on the shore of Portland Roads; and it is calcareous, effervescing strongly with muriatic acid.

* Lyell's Geology, p. 47, vol. ii. 4th ed. I was induced to visit the Chesil Bank from reading this statement, and I carefully tested the pebbles by muriatic acid.

† On November 23, 1824, the Ebenezer, Ordnance sloop, got embayed here, and had to be run on shore. The vessel stood on to the Chesil Bank, under her jib, and was carried up to the top of the bank; and she was some time afterwards launched into Portland Road. The Ebenezer is still in the Ordnance service.

Scarcely any gravel is to be seen between Portland Roads and Weymouth. Within the Abergaveny, an East India ship, which sunk 30 years ago in the mouth of Weymouth Bay, there is no gravel, and but little sand.* East of Weymouth it again begins to collect; but each little headland, acting as a groin, retains much of it in the small bays. Round St. Alban's Head its action has not been observed, but at Christchurch the quantity is considerable, and at Hurst Castle it is very large.

Christchurch and Hurst Castle.

The Isle of Wight, and the strong current running through the Needles, here again a second time stop its eastward movement; and it forms, nearly in the mid-channel, a shoal called the Shingles, the easternmost end of which (by the action of the westerly winds on one side, and the current of the Needles on the opposite,) becomes heaped up above high-water mark into an island, varying in shape and size with every storm, and sometimes disappearing altogether.

The Shingles.

The pebbles coming from the westward must be driven across the north channel to this bank; but they do not pass across the south and principal channel of the Needles to the Isle of Wight, as is evident from local inspection; for those of the Isle of Wight are of a different colour, being black flints from the chalk, whereas those on the side of Hurst Castle are generally yellow.

Isle of Wight.

The effect of the prevailing wind, in driving the gravel along the coast from west to east, is not less evident on the south of the Isle of Wight than elsewhere. It passes eastward until it reaches Sandown Bay, where the artificial groins, kept up at considerable cost, arrest a certain portion; but the surplus is poured over these groins, and falling on the east side continues its course.

The gravel which passes Portsmouth does not appear to come from the westward of Hurst Castle, for the shores just within the Needles are mud without stones. A new system commences within the Solent. A large quantity of shingle is furnished from the gravelly soil of the south coast of Hampshire; and this shingle is likewise driven eastward, sometimes returning westward when easterly winds prevail, but the balance of its progress is always towards the east.

Portsmouth.

Hurst Castle, Calshot Castle, and Blockhouse Fort, Portsmouth, all stand on similar tongues of shingle, formed on the west sides of their respective passages by the prevailing westerly winds.

* Mr. Dean was employed for several days lately examining this wreck.

CHART

to accompany a Paper

on the

DRIFTING OF THE SHINGLE

by the

PREVAILING WINDS

Scale of Miles

0 1 2 3 4

Engraved by J. Gardner Regent Street London.

Ancient lines of high-water mark visible.

At Hurst Castle, the gradual additions to the end of the strip of shingle may be plainly seen; for Nature there records her own history in a very visible manner. An ordnance landing-place 30 feet long, which was constructed thirty years ago, and stood in the sea, is now entirely buried in gravel; and many succeeding lines of high-water mark may be distinctly traced to the eastward of Hurst Castle.

Similar traces of many former lines of high-water mark are also to be seen near Southsea Castle; and immediately on the west of Fort Monkton, six distinct lines of high-water may be counted; and some of these probably belong to very remote periods of time.

The direction of the line of coast, with reference to the prevailing gales, seems to determine where the shingle will accumulate, or where the sea will be most likely to encroach upon the land; and seems to be one of the most important points to study as regards the subject of opening bar-harbours.

The south-easterly direction of the beach at Southsea, would appear to be one of the causes why the entrance of Portsmouth Harbour is kept as clear as it is, by the current running out of it; for this direction of the land prevents the water from spreading itself on both sides, at the ebbing tide, as it does at the entrance of Langston Harbour, over banks of gravel; and this direction at Southsea appears just sufficient to allow the shingle to be set to the eastward by the prevailing gales.

Opening bar-harbours.

It well deserves consideration, whether embankments (on the south coast of England,) run out on the eastward of bar-harbours, in a line parallel to the line formed by nature on the east side of Portsmouth Harbour, would not lead to a similar effect as that produced there in keeping open one principal channel. By a proper system of groins on the west side of such harbours, shingle coming from the westward would be stopped, and much of the materials which now form the bars might be arrested in their course.

The slope of the beach is flatter after a southerly gale, and its average slope is about 1 foot in 9.

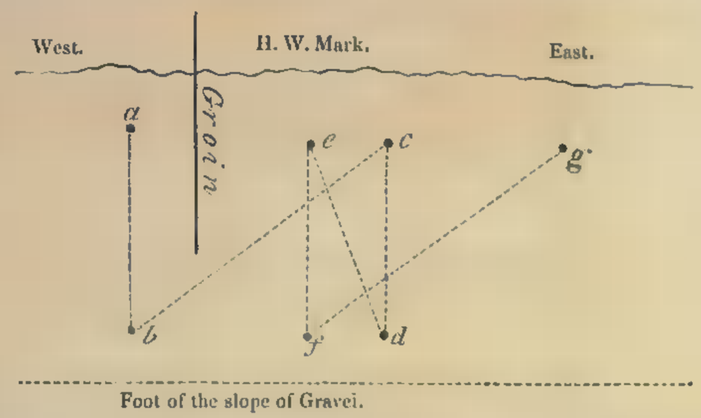
Groins.

If groins are not carried far enough in-land, the sea in south-west storms (on the south coast) will break round and insulate them. If they are not high enough at high-water mark, the gravel will be carried over them to the eastward; and if they are too short, it will pass round the outer end of them.

During southerly gales, it is frequently said, that the gravel is "carried into

the sea," because the receding waves draw it down; but it is again driven back, and if the wind be south-west it is set to the eastward.

The annexed figure, in which a pebble (a) passes to (g), following a course indicated by the alphabetical order of the letters, will explain what is here meant, and show the way in which the gravel passes by groins which are too short.



Foot of the slope of Gravel.

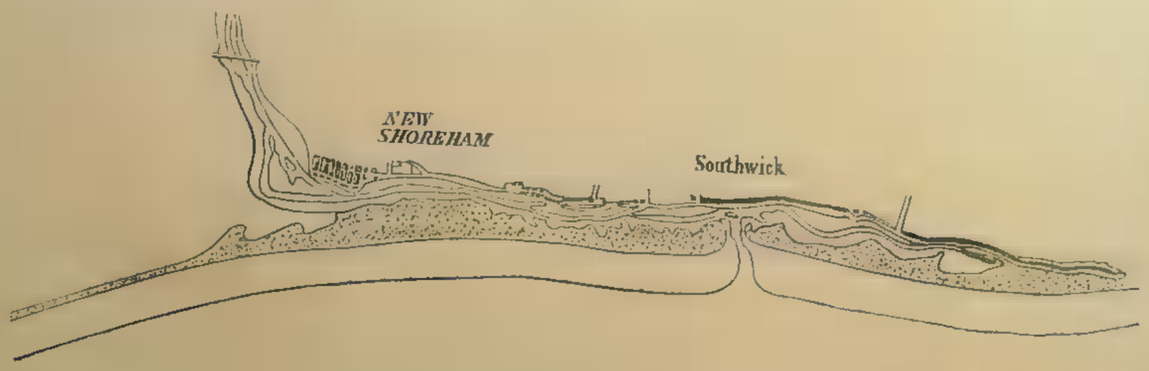
From this figure it will also be understood, why a single plank removed from a wooden groin will cause the beach at such place of removal to be carried on forward; and hence the importance of constructing groins of materials not liable to such accidents.

Calshot.

The point of shingle on which Calshot Castle now stands, was once an island, and called, in 1717, Crown Island; since which time the opening has filled in with gravel.

Christchurch Harbour.

The point on the west side of Christchurch Harbour is now lengthening annually; and the mouth of that harbour and its bar become every year more and more removed to the eastward, and if left to nature may continue to be removed eastward until the water from that estuary shall re-open a fresh passage for itself in a more direct line, as the water seems to have done at the harbour of Shoreham.



At such harbours as Portsmouth, it would be desirable, by means of the apparatus for enabling persons to descend and examine the bed of the sea, to observe and determine the precise mode of the action of the shingle at the entrance of harbours.

The sand being blown by the wind, as well as driven by the surge, it frequently covers the coarser shingle, where it is retained by the *carex arenaria*, a grass which roots at every joint.

Much valuable information on the subject of encroachments of the sea upon the land, will be found in Lyell's Geology, book ii. chap. 6.

I was not aware until after the types were set for this article, that the same subject had engaged the attention of Mr. De la Bêche; and that a paper upon it by Mr. Palmer, Civil Engineer, had been read before the Royal Society in 1834, and printed in their Transactions for that year.

I have since read this paper, which relates to the coast of Kent and the eastern portion of Sussex; and Mr. Palmer, in explaining his observations on the effects caused by the waves, points out the great importance of the subject.

Mr. De la Bêche has explained to me, that it is rather the prevailing *wave* than the prevailing *wind*, which produces the effects of so much consequence at the mouths of rivers and estuaries; and we may hope, in our next volume, for a paper in further explanation of the subject from him.

WM. REID.

XIV.—*Coast Defences in Holland. By Captain* Sandham, *Royal Engineers.*

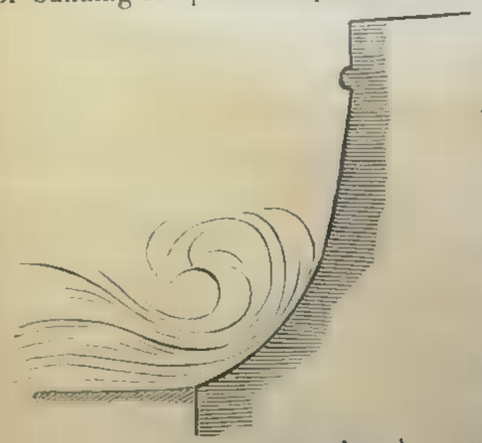
The editor's note to the description of groins used on the coast of Sussex for preventing the encroachments of the sea, by Lieutenant (now Captain) Luxmoore, Royal Engineers, induces me to send these details of the method followed on the coast of the Netherlands for the same object; only it should be kept in mind, that the English coast of the channel has a shingle beach, whereas that of the Netherlands is of sand, and the object there is to protect a low country from inundation by the sea, by accumulating sand, and strengthening sand-hills. These observations were made as far back as 1815, since which period, probably, other methods may have been adopted, and refer to that part of the coast near the village of Blankenberg, about ten miles east of Ostend, which is situated under the sand-hills, in a country nine feet below the level of high water. Numerous jetties of clay were formed, abutting on the sand-hills, running out towards the sea, perpendicular to the general line of the coast, and according in length with its sinuosities, many of them being several hundred feet long: they were formed by excavating a foundation twenty feet wide and three feet deep in the sands, into which clay was deposited, well rammed, and heaped into a rounded form, rising in the centre five or six feet above the level of the sands: the whole surface of the jetty was then covered longitudinally with layers of straw twisted (as the operation went on) into bands, and forced, at short intervals, by a spud or blunt chisel, deeply into the clay, which gave it the appearance of being covered with a matting of straw, and prevented the sea from immediately acting on the clay: strong pickets, from five to six feet long, were then driven into the jetty, between every second or third layer of straw, about one foot or eighteen inches apart, and strong brushwood was worked in hurdle-work round them, to the height of eighteen inches, when the pickets were driven home as far as the hurdle-work would admit, and the work was completed; it however could only be carried on whilst the tide was out, and as it would not do to leave the clay unprotected to the action of the sea, short portions were undertaken and completed at the time. It is a very expensive work; and notwithstanding the care that may be bestowed on it, is very subject to being breached by the sea, and otherwise requires constant attention and repair.

The accumulation of sand against these jetties was very rapid, and more particularly so in the angles formed by the jetties and the sand-hills, where, as soon as it had accumulated above the reach of the tide, it was retained by planting it with a rush provincially called chéne, (*carex arenaria*) a native plant of the sand-hills, of quick growth, throwing out long fibrous roots, from which innumerable tufts spring up; against these plants the drift sand lodges, and finding its way into the centre of each tuft, occasions them to spread, and nourishes them; for hardly are they covered with sand before the rushes thus spread, grow through and form a new nucleus, round which the drift sand again collects, and this process continues until the sand-hills are formed.

The sand collected by the jetties is not washed against them by the action of the sea, but is stopped by them as it drifts from the surface of the sandy beach at low water, the sea receding at the part referred to probably a mile; and the wind, blowing almost always from the west, dries the surface sand, and drives it in great sheets constantly moving towards the jetties prepared to detain it. When the wind is high, the drift of sand is so great, and moves with such force, that it is almost impossible to walk against it.

In situations where there is any immediate danger to be dreaded from the weakness of the sand-hills, a sea-wall of stone is built on a bed of clay, at a slope of about one to two; greater or less according to circumstances and localities.

I cannot conclude this communication without pointing out the advantages of building scarp-walls exposed to the action of the sea; on this profile, (*fig.* 1)



it leads the waves up the wall, until they fall over on themselves, without injuring the wall; the most common profile of a scarp wall exposed to the sea (*fig.* 2) now in use, is intended to resist the sea, the lower courses being built in rustic-work, giving a hold to each successive wave that must at last displace them, and eventually bring down the wall: it is very evident, more is to be done by leading the constant action of so irresistible an element than by opposing it.

Another advantage of the circular foot to the revetement exposed to the sea is, that a boat could not lay along side of it, as the wave that would carry it up the face of the wall, if any attempt should be made to keep it there, would, in receding from it, leave it to be rolled over in sliding down the circular part. There is a scarp at Cadiz built on this profile, exposed to the roll of the Atlantic, and is in good order, whilst other parts of the scarp, in less exposed situations, have been repeatedly breached by the sea.

H. SANDHAM,
Captain, Royal Engineers.

October 1837.

XV.—*On Hurricanes.* *By Lieutenant-Colonel* Reid.

The object of the present article is to draw the attention of officers of Engineers serving within the tropics to the subject of hurricanes. They are highly interesting phenomena, not only in a meteorological point of view, but as connected with the art of building within the range of their influence; for the effect of the wind in violent hurricanes is much more destructive than is easily imagined by those who are unacquainted with the subject.

There appears to be now no doubt, but that the West Indian hurricanes are identical with the storms which sweep with fury on the coasts of the United States of America. Dr. Franklin, who studied meteorological subjects on those coasts, called these storms north-east storms, and he was aware that they generally came from the south-west; but he believed that the direction of the wind was rectilinear. This is still the commonly received opinion; and the late Professor Leslie of Edinburgh based a calculation on the hypothesis, that the wind in hurricanes moves at the rate of 120 miles an hour,* in a rectilinear direction. Franklin.

When employed in Barbadoes, re-establishing the buildings ruined in the hurricane of 1831, curiosity led me to inquire into the history of former storms; but the West Indian records contain little beyond details of the losses in lives and property, and make no attempt to furnish data, whereby the causes or the courses of these hurricanes may be investigated.

Their causes may for ever remain secret; but we are indebted to Mr. Redfield of New York for having collected data sufficient to lay down some of their courses. Redfield.

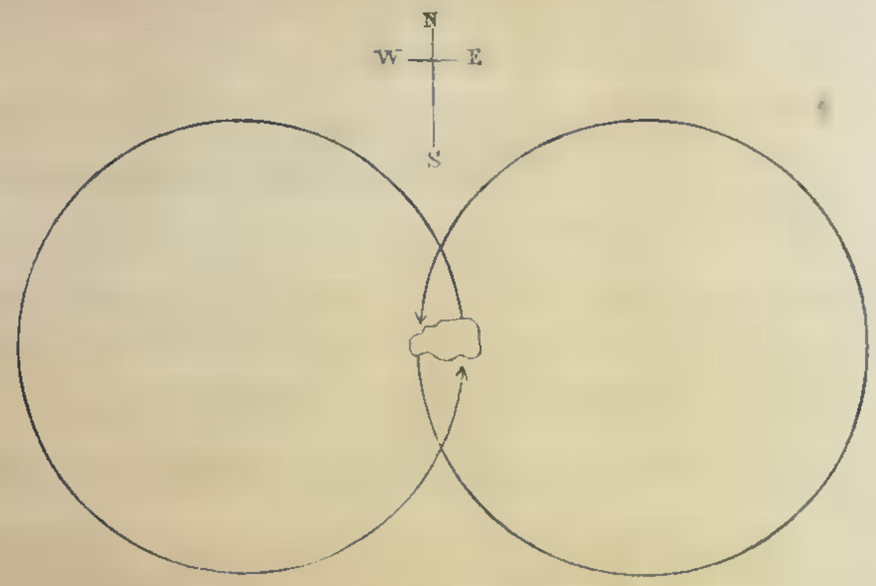
These courses (particularly that of 1830, Chart I.) appear to prove, beyond a doubt, that Dr. Franklin's north-east storms coming from the south-west were, in some cases at least, West Indian hurricanes; but that instead of the wind blowing in a rectilinear direction, it sweeps in curves; and also, that hurricanes

* See Daniell's Meterological Essays, 2d edition, page 4.

are progressive whirlwinds of great diameter, carried along in the general atmospheric current of that part of the atmosphere in which they form. From the recorded observations, they appear to turn from right to left, (supposing yourself standing in the centre) or in the opposite way to the hands of a watch.

Hurricanes frequently cease to blow at the opposite quarter to that from which they commenced.

The following figure shows that this will occur if they are progressive whirlwinds, and that there may be a lull, or calm, as the centre of the vortex is passing over places in its track.



In the above figure, such a whirlwind coming from the eastward is supposed to pass over an island in the middle of its course. The wind would at the commencement be at the eastward of north, or nearly north; and it would be at the end at the westward of south, or nearly south.

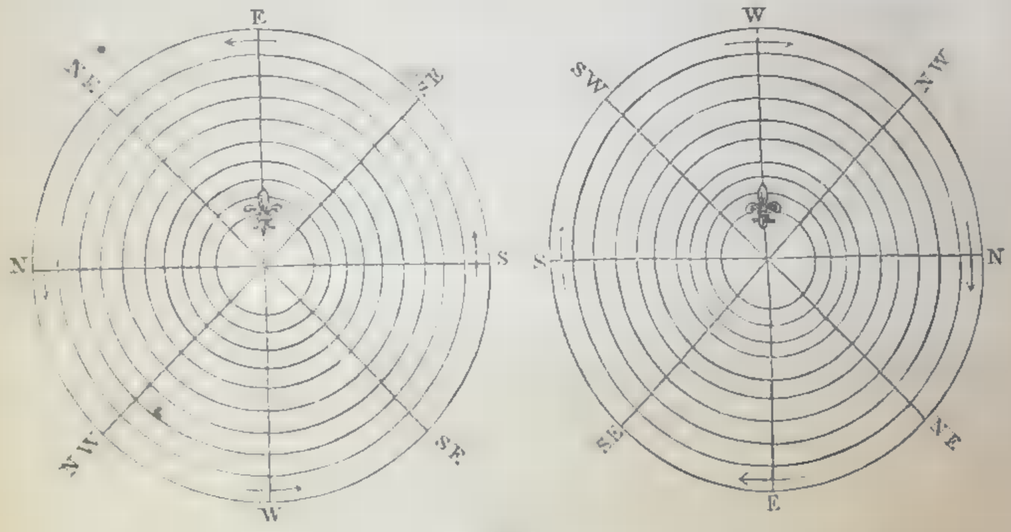
Reader to construct a figure.

The simplest method of following the reports of the storms in this article, is to describe sets of concentric circles on separate pieces of paper, like the two following figures, and then cutting them out and using them as representing progressive whirlwinds; the veering of the wind will be easily understood.

Storms.

The first figure represents a whirlwind turning from *right* to *left* (supposing yourself in the centre): and this figure will be found to be the one agreeing with the reports of the wind in the storms of the northern hemisphere.

North.



South.

When these figures are made to move over a fixed spot, as an island, or over a ship, in the general course the storms took, they will help to explain the veering of the wind.

Mr. Redfield of New York has published the following recorded observations, made at different places, both on land and in ships at sea, of the hurricane of August 1830, from which its course on the Chart I. has been laid down: the general atmospheric current blowing over the North American continent at this period was north-west; so that the hurricane, at first borne from the east towards the west, was bent to the north, and finally to the north-east.

Mr. Redfield's data are as follow:

Data for Chart I.

"This storm or hurricane was severe at the island of St. Thomas, on the night between the 12th and 13th of August, 1830.

"On the afternoon of August 14, and the succeeding night, it continued its course along the Bahama islands, the wind veering almost round the compass during the existence of the storm.

"On the 15th of August the storm prevailed in the Florida channel, and was very disastrous in its effects.

"In latitude 26° 51′, long. 79° 40′, in the Florida stream, the gale was severe on the 15th, from north-north-east to south-west.

"Late on the 15th, off St. Augustine (Florida,) in lat. 29° 58′, long. 80° 20′, the gale was very severe.

" At St. Andrew's, twenty miles north of St. Mary's (Georgia), from 8 o'clock P. M. on the 15th, to 2 A. M. on the 16th, the storm was from an eastern quarter, then changed to south-west, and blew till 8 A. M.

" Off Tybee, and at Savannah (Georgia,) on the night of the 15th, changed to north-west at 9 A. M. on the 16th, and blew till 12 M.

" At Charleston (S. C.) on the 16th the gale was from the south-east and east, till 4 P. M., then north-east, and round to north-west.

" At Wilmington (N. C.) the storm was from the east, and veered subsequently to the west.

" In the interior of North Carolina the storm was felt at Fayetteville.

" In the vicinity of Cape Hatteras, at sea, the storm was very heavy from the south-east, and shifted to north-west.

" A vessel bound from New York to Hayti, in the middle or outer part of the Gulf-stream, about lat. 33°, long. 72°, experienced the gale moderately from the south-west and south-south-west, but with a very heavy sea from a westerly direction, and is supposed to have been on the outer margin of the storm.

" Another vessel, at about the same distance from the coast, experienced similar effects.

" Early on the morning of the 17th the gale was felt severely at Norfolk, and also in Chesapeake Bay, from the north-east.

" Off the Capes of Virginia, on the 17th, in lat. 36° 20′, long. 74° 2′, ' a perfect hurricane,' from south to south-south-east, from 5 A. M. to 2 P. M., then shifted to north-west.

" On the 19th, in lat. 37° 30′, long. 74° 30′, near the east of Virginia, the gale was severe at east-north-east, and changed to west-north-west.

" Off Chincoteague (Md.) precise distance from the coast unknown, the gale was severe between south-south-east and north-north-east.

" Off the coast of Delaware, in lat. 38°, long. 72°, ' tremendous gale,' commencing at south-east at 1 P. M. on the 17th, and blowing six hours, then changed to north-west.

" At Cape May (N. J.) the gale was north-east off Cape May, in lat. 39°, long. 74° 15′; heavy gale from east-north-east on the afternoon of the 17th of August.

" Near Egg Harbour, coast of New Jersey, the gale was heavy at north-east on the same afternoon.

" Off the same coast, in lat. 39°, long. 73° the gale was at east-north-east.

" In the same latitude, long. 70° 30′, ' tremendous gale,' commencing at south-south-east and veering to north.

" At New York and on Long Island Sound, the gale was at north-north-east, and north-east on the afternoon and evening of the 17th.

" Off Nantucket Shoals, at 8 P. M., the gale commenced severe at north-east by east.

" In the Gulf-stream, off Nantucket, in lat, 38° 15′, long. 67° 30′, on the night of the 17th, ' tremendous hurricane,' commencing at south, and veering with increasing severity to south-west, west, and north-west.

" At Elizabeth Island, Chatham, and Cape Cod (Mass.), the gale was severe at north-east, on the night between the 17th and 18th of August.

" On the 18th, heavy gale from north-east, at Salem and Newbury Port (Mass.)

" Early on the 18th, in lat. 39° 51′, long. 69°, severe gale from south-east, suddenly shifting to north.

" In latitude 41° 20′, long. 66° 25′, ' tremendous hurricane' from north-north-east on the 18th of August.

" On the night of the 18th, off Sable Island, and near the Porpoise Bank, in lat. 43°, long. 59° 30′, ' tremendous gale' from south and south-west, to west and north-west.

" In lat. 43°, long. 58°, severe gale from the south, the manner of change not reported. This remarkable storm appears to have passed over the whole route comprised in the foregoing sketch in about six days, or at an average rate of about seventeen geographical miles per hour.

" The duration of the most violent portion of the storm, at the several points over which it passed, may be stated at from seven to twelve hours.

" The general width of the track, influenced in a greater or less degree by the gale on the American coast, is estimated to have been from five to six hundred miles.

" Width of the hurricane portion of the track or severe part of the gale, one hundred and fifty to two hundred and fifty miles.

" Semidiameter of the hurricane portion of the storm, seventy-five to one hundred and twenty-five miles.

" Rate of the storm's progress from the island of St. Thomas to Providence Island, Bahamas, fifteen nautical miles per hour.

" Rate of progress from Providence to St. John's, Florida, sixteen miles per hour.

" From St. John's to Cape Hatteras, North Carolina, sixteen and a half miles an hour.

" From Cape Hatteras to Nantucket, on the south-eastern coast of Massachusetts, eighteen miles per hour.

" From Nantucket to Sable Island, off the south-eastern coast of Nova Scotia, twenty miles per hour."

When these points are laid down and tried, it will be found that, to conceive the wind in its progress to have a gyratory motion, will be sufficient to explain all the changes recorded; ships nearest the centre of the vortex being affected by the most sudden shifting of the wind. By a general view of its course, it will be perceived, that on the land of America, the wind in this storm was north-east, north, and north-west, on one of its semicircles; whilst on the other side, it was south-east, south, and south-west.

Ship Illinois.

The positions of the ship Illinois, during three different days, have been placed on the chart; and an extract of a letter from the master is of sufficient interest to be re-printed.* By his account, it appears that he had passed through

Master of Illinois' letter.

* Extract of a letter from the master of the ship Illinois.

" I sailed from New Orleans on the 3rd of August, bound to Liverpool.

" Nothing worth notice occurred until the 15th August, in lat. 33° N. long. 77° W.; when there was a very heavy swell from the south, more than I had ever experienced before in

the Gulf of Florida, and across the tract over which the hurricane afterwards passed, before it arrived. On the 15th, the swell which it occasioned overtook him; and on the 17th he was overtaken by the storm itself, blowing at south, the Illinois being then in its eastern semicircle. The position of the Britannia, a ship which had sailed from New York the evening before, with fine weather, is also marked. This last ship received the wind first from the north-east and east-north-east, on the night of the 17th, but after midnight she had it from the east-south-east; she may therefore have passed across the centre of the track, and at the time when it is reported to have been a "perfect hurricane," with a "tremendous sea, beyond description."

Ship Britannia.

In addition to the observations collected by Mr. Redfield, the place of the British frigate Blanche, on the 15th August, 1830, is marked on Chart I.

On the 12th she was off Matanzas, with the wind varying from north-east to easterly; and on the 15th she sailed into the track of the hurricane.

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this part, unless preceded by heavy gales. We had no indication of wind at this time, but there was a dull and heavy appearance in the south. During the day the wind was light and at S.E. at night it shifted S.S.W.

"On the 16th it was a fresh wholesome breeze; so that with the help of the Gulf-stream we ran at a great rate, steering N.E., and at noon we were in lat. 36°, long. 73°.

"The 17th the wind continued steady at S.S.W. blowing a strong wholesome breeze, but the appearance *to the south continuing dull and heavy:* the sea was smooth again, and we seemed to have outrun the southerly swell. At noon, lat. 37° 58′, long. 69° 23′, we were still continuing to run about the course of the Gulf-stream. The temperature of the water was 86°. On the first part of the 18th (afternoon of the 17th, current time,*) the wind backed to south, and began *to freshen-in very fast;* some heavy clouds arising in the S.W. with flashes of lightning in that quarter. At 8 P.M. the wind had increased to a strong gale: the weather at this time had an unusual appearance, but still it did not look bad.

"At 10 the wind had increased, and we took in our sails and prepared for the worst.

"At 11 o'clock the sea ran high *and cross*, which induced me to heave the ship to, under a close-reefed topsail.

"At half-past 12, midnight, all was darkness; the heavy clouds which had been rising in the S.W. had overtaken us; the rain fell in torrents, and the lightning was uncommonly vivid; the wind had, in the space of an hour, increased from a moderate gale to a perfect hurricane.

"At half-past 1 A.M. it began to veer to the westward.

"At 3 A.M. it was west, and rather increased in violence as it shifted.

"At daylight *the sky was clear*, but the gale, if anything, rather increased in its fury; the sea was tremendous, and ran in every direction.

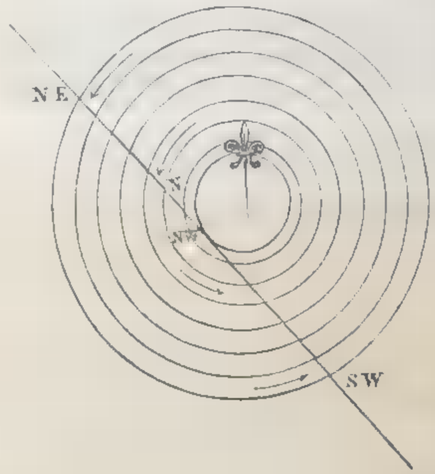
"At 7 the wind had got to the N.W. and at 9 it began to abate a little.

"I have only to add, that from an experience of twenty or thirty years, during which time I have been constantly navigating the Atlantic, my mind is fully made up, that heavy winds or hurricanes run in the direction of whirlwinds.—Believe me, &c.

(Signed) "ROBERT WATERMAN."

* *Civil time.*

The following figure, together with a copy of the log, which has been procured from the Admiralty, will show in what a remarkable manner the veerings of the wind (with the exception of the last one) agree with what it would be in a progressive whirlwind passing over the ship, in the direction of the line in the figure which cuts the concentric circles. Blanche's log.



Extract from the Log of H. M. S. Blanche, Commodore Farquhar, kept by Mr. Middlemist, Master R.N. in *civil time.*

H.	K.	F.	Courses.	Winds.	Remarks, &c. H.M.S. Blanche, August 15th, 1830.
	3	....	N.N.W.	N. Easterly	A.M.—Fresh breezes and squally; tried for soundings half-hourly 3.30—Down fore-topmast staysail and set fore-staysail; close reefed mizen-topsail. 4—Ditto weather. 4.30—Close reefed fore-topsail, and reefed foresail and set it. 5.30—Wore;—close reefed main-topsail; furled fore and mizen-topsails; down top-gallant-yards and masts; in flying jib-boom; reefed and furled mainsail. 8—Strong gales, with violent squalls; ship pitching and working heavily. 9—A hurricane. Getting in jib-boom ship made a heavy plunge; lost the boom, spritsail-yard and jib, and three seamen, who were unfortunately drowned. Cut away life-buoy, but to no effect; both bumkins went in about the same time. 9.50—Both fore-topmast stays went. 10—Fore-topmast carried away close to the cap, and fell with topsail-yard on fore-yard, springing it in the starboard quarter; main-topmast stay carried away; got a hawser up and secured the masts; fore and main courses split and blew away; starboard cutter filled, cut her adrift, lost her gear; split fore staysail down, ditto and trysail; violent hurricane and heavy sea; scuttled lower deck, and worked chain-pumps. 11—Washed away starboard lt. nettings. 11.30—Wind shifted to N.W., and blew more violently; bowsprit shroud carried away.
2	3	....	N.N.W. ½ W.		
3	3	2			
4	2	6			
5	2	....	N.W. by N.		
6	½	....	E. ½ S.	Northerly	
7	} ..	.. {	Head from E.		
8	}	{	to S. to S.E. by E.		
9	}				
10	} ..	....	from E. to N.E.	N. Westerly	
11	}				
12	....	....	Head to N.E.		

Course.	Dist	Latitude observed.	D. R.	Longitude Chronometer	D. R.	Bearings and Distance.	R. W.
N.E.	115	None.	27° 15′ N.	—	79° 35′ W.	Matinilla Reef, N.E. ½ E. 30 miles.	78½

Extract from the Log of H. M. S. Blanche—*continued.*

H.	K.	F.	Courses.	Winds.	Remarks, &c. H. M. S. Blanche, August 15th, 1830.
1	..	....	.....	S. Westerly	P.M.—Ship laying over so much as to bury the starboard quarter-gallery, that in rising it was completely stove, as well as the dead-lights lost, with fore-topsail, top-gallant, and roval staysail.
2	..	..	up W. off W. N.W.		2—More moderate; set main-staysail. 3—Split ditto; bent a new one.
3	..	..			
4	..	..			4—Ditto weather; set main-staysail; jolly-boat filled, carried away larboard tackle, cut her adrift, lost her gear.
5	..	..	from N.E. by N. to N.W.		6—Lashed the wreck of fore-topsail and topsail-yard to the ship; swifted main rigging; found bowsprit, mainmast, and fore-yard badly sprung.
6	..	..			
7	....	....	.....	W. by N.	8—Strong gales and squally; tried repeatedly to put the ship before the wind.
8	..	..	from W. by N. to N.W. by W.		
9	..	..			
10	..	..			
11	..	..			
12	..	..			Midnight; strong gales and squally weather.

The probable extent as well as track of the storm may be inferred from an inspection of the chart.

The log of the Blanche gives the general atmospheric current, as north-east and easterly off Matanzas, on the 12th; the master of the Illinois, on the 15th, states it as south-easterly where he was; and on the continent of America it was reported to have been north-west.

Diameters of storms enlarge.

The diameters of the storms appear to enlarge as they proceed, and proportionally to diminish in violence. The charts, being constructed on Mercator's projection, will however tend to give a somewhat exaggerated appearance to this effect. It will also be observed, that the curves are made circular throughout the charts. It will be time enough to investigate the nature of the curves in great storms after they shall have been proved to revolve.

Chart II. shows the course of a hurricane in 1821, traced by Mr. Redfield; and the bearings of the wind are carefully laid down from his data.

It will be seen by the inspection of the chart, that the general course of the wind on the right-hand side of this progressive storm, (as well as in that described on Chart I.) was in a contrary direction to the wind on the left-hand side: and there appears to have been no storm to the east or to the west of its course at the same period.

Trees laid in opposite directions.

But the most remarkable fact recorded regarding this one is, that in the States of Massachusets and Connecticut the trees were blown down on the eastern portion of those states with their heads to the north-west, whilst those in the western portion were prostrated with their heads towards the south-east.

The following is the data on which Chart II. is laid down, and which is taken from the "American Journal of Science," vol. xx:— Hurricane of 1821.

"The earliest supposed trace of this hurricane which has been obtained, is from off Turk's Island, in the West Indies, where it appeared on the 1st of September, 1821, two days previous to its reaching our coast. It was felt there severely, but at what hour in the day we are not informed.

"The next account we have is from lat. 23° 43′, where the storm was severe on the 1st September, from south-east to south-west. Whether these two accounts are considered as identifying the storm, or otherwise, will not at this time be deemed material.

"Our next report is from lat. 32° 30′, long. 77° from Greenwich, on the night of the 2nd of September, a hurricane for three hours.

"At 3 A.M. on the 3rd of September, a severe gale was experienced 30 miles outside of the American coast, off Wilmington, N. Carolina.

"At Wilmington there was no gale.

"At Ocracock Bar, N. C., at daylight on the morning of the 3rd, a severe gale from E.S.E.

"At Edenton, N. C., the gale was at N.E.

"Off Roanoke, on the morning of the 3rd September, a dreadful gale at E.: then S.W. and N.W.

"A vessel from Charleston, S. Carolina, two days previous to arriving in the Chesapeake, experienced the gale at 4 A.M. on the 3rd, from S.E. to W.S.W.

"A vessel from Bermuda experienced the gale from the westward, on the inner edge of the Gulf-stream.

"Another vessel from Charleston did not experience the gale.

"In lat. 37° 30′, on the inner edge of the Gulf-stream, gale from the westward with squalls.

"On James River, Virginia, the gale was severe from the north-west.

"At Norfolk, Virginia, the gale raged on the 3rd for five hours, from N.N.E. to N.N.W., and terminated at the latter point: greatest violence at 10 A.M. to 1 P.M.

"At sea, forty miles north of Cape Henry, severe at S.E., changing to N.W.

"Off Chincoteague, coast of Maryland, gale from the S.E. on the 3rd.

"At Snowhill, Maryland, gale commenced at 11 A.M.

"In lat. 38° 30′, long. 74° 30′, gale south by east.

"A ship from Boston, bound to Norfolk, experienced nothing of the gale. On the 3rd, was in lat. 40° 19′, weather foggy, and light winds from S.E.

"At Morris River, Jersey, the gale was E.S.E.

"No hurricane was felt at Baltimore.

"At Cape Henlopen, Delaware, the hurricane commenced at half-past eleven A.M. from E.S.E.; shifted in twenty minutes to E.N.E., and blew very heavy for nearly an hour. A calm of half an hour succeeded, and the wind then shifted to the W.N.W., and blew, if possible, with still greater violence.

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4					4—Ditto weather; set main-staysail; jolly-boat filled, carried away larboard tackle, cut her adrift, lost her gear.
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"At Cape May, New Jersey, commenced at N.E. at 2 P.M. and veered to S.E. and blew with violence: after abating fifteen minutes, it again blew with increased violence for two hours and then abated. The sun set clear with pleasant weather, at which time not a cloud was to be seen in the *western* horizon.

"At Bombay Hook, near the mouth of the Delaware river, the gale blew from the N.N.E. and W.N.W.

"At sea, forty miles north-east of Cape May, the gale was at S.E. and lasted eight hours.

"At Philadelphia, the storm commenced at 1 P.M. on the 3rd from the N.E., and raged with great violence from N.E. to N.W. during the greater part of the afternoon.

"At Trenton, New Jersey, the gale commenced at 3 P.M. with the wind at N.E.

"In lat. 39° 20′, long. 73° 30′, the gale blew from the E.S.E. and S.S.E., and lasted eight hours.

"At New York, the gale was from N.E. and E., and commenced blowing with violence at 5 P.M.; continued with great fury for three hours, and then changed to the west. More damage was sustained in two hours than was ever before witnessed in the city; the wind increasing in the afternoon. *The wharves were overflowed, rising thirteen feet in one hour.* Previous to the gale the wind was from S. to S.E., *but changed to* N.E. at the *commencement of the storm*, and blew with great fury until the evening, and then shifted to the westward.

"At the Quarantine, Staten Island, the wind was reported at E.S.E.: other accounts fix it at east.

"At Bridport, Connecticut, the gale commenced violent at S.E. at 6 P.M. and continued until 9 P.M., then shifted to N.W., and blew until nearly 11 P.M.

"At New London the gale was from 7 P.M. until midnight.

"At Middleton, Connecticut, violent from S.E. for five hours.

"At Springfield, Massachusets, violent from 9 to 12 P.M., then changed to the westward.

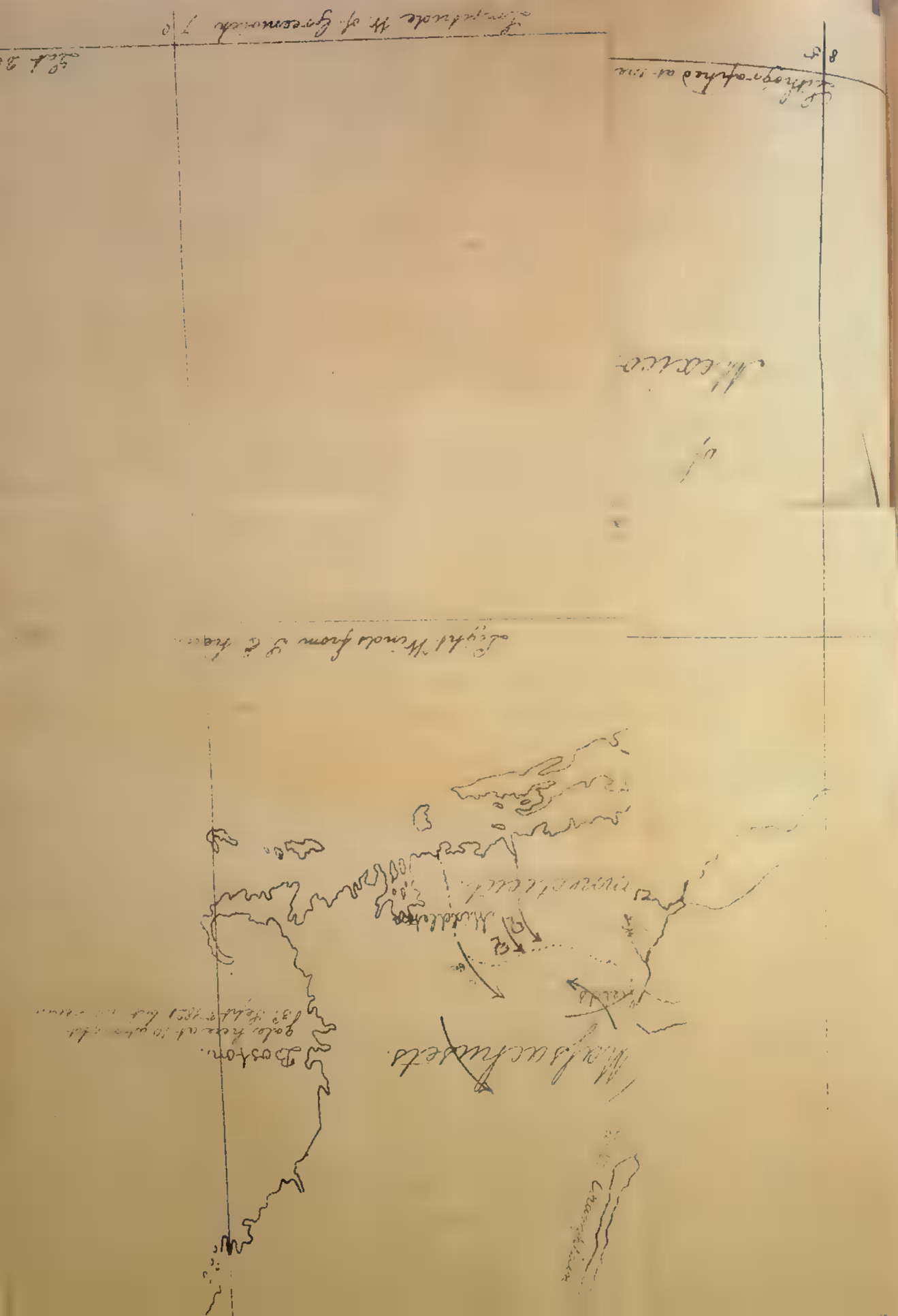
"At Northampton, at S.E. on the same evening.

"At Worcester, Massachusets, in the night between the 3rd and 4th September.

"At Boston, the gale commenced at 10 P.M., but was not severe. At the time the storm was raging with its greatest fury at New York, the inhabitants of Boston were witnessing the ascent of a balloon, and the aëronaut met with little or no wind.

"The general course of this storm, northward of Cape Hatteras, appears to have been S.S.W. and N.N.W.; and of its further progress we are uninformed."—'American Journal of Science,' vol. xx. p. 24.

The progressive rates of hurricanes seem to depend upon the strength of the general atmospheric current at the time; and Mr. Redfield gives eleven reports of another storm, which he traced from the Bahamas, and which appeared to have advanced at the rate of only ten miles an hour. Owing to this slow rate of progress, its duration was prolonged at each place over which it passed; and the increase of its diameter, as it proceeded northward, would further prolong its



duration wherever it came. On the coast of the North American States it lasted forty hours; from which we infer that its diameter was 400 miles.

The great hurricane of 1831 has been traced to the southern States of the Union, (as marked on Chart III.) where it is supposed to have ended. The facts related of this hurricane support Mr. Redfield's opinions. In one of his published papers he observes, that "of the storms of the last forty years, it is believed the route and corresponding character of all, which have received notice in the marine reports, may be traced in a similar manner, while not an instance of a contrary kind has come to his knowledge." Barbadoes hurricane of 1831.

The hurricane of the 10th of August, 1831, began at Barbadoes, with the wind N.E., N.N.E., and N., at 11 at night, or between that and midnight. The following account of its duration is copied from a published narrative, by the editor of the West Indian newspaper, who was at Bridgetown, Barbadoes, when it occurred:

"After midnight the continued flashing of the lightning was awfully grand, and a gale blew fiercely from the north and north-east; but at 1 A.M. on the 11th of August, the tempestuous rage of the wind increased, the storm, which at one time blew from the north-east, suddenly shifted from that quarter, and burst from the north-west *and intermediate points*. The upper regions were from this time illuminated by incessant lightning; but the quivering sheet of blaze was surpassed in brilliancy by the darts of electric fire which were exploded in every direction. At a little after 2, the astounding roar of the hurricane, which rushed from the north-north-west and north-west, cannot be described by language. About 3, the wind occasionally abated, but intervening gusts proceeded from the south-west, the west, and west-north-west, with accumulated fury. The wind sunk again to a solemn murmur, or to speak more correctly, to a distant roar."

At this period, the lightning is described by the author to have "passed upward from the earth to the clouds, and to have returned again with novel and surprising action."

"The moment after this singular alternation of lightning, the hurricane again burst from the western points with violence prodigious beyond description. No thunder was at any time distinctly heard. The horrible roar of the wind,* the noise of the ocean, which threatened the town, the clattering of tiles, the falling of walls and roofs, formed an appalling din. This uproar continued until half past 4 A.M., the wind coming from the west and other

* The Lieutenant-Colonel commanding the 36th regiment, who had sought protection by getting under an arch of a lower window, outside his house, did not hear the roof and upper story fall; and was only assured this had occurred, by the dust caused by the falling ruins.

points to the southward of west. At 5, the storm now and then for a few moments abated, in which intervals the falling of tiles and building materials, *which by the last gust had probably been carried to a vast height*, were distinguished.

"At 6 A.M. the wind was at south, and at 7 south-east; at 8, at east-south-east."

Rate of travelling.

Now if the wind in this hurricane travelled at the rate of 100 miles an hour, and in a rectilinear course, it would have reached St. Vincent's, which is only about seventy or eighty miles to the westward, in less than an hour; but it did not reach that island until 7 o'clock on the morning of the 11th. It was therefore seven hours in its progress; which gives a rate of about ten miles an hour.

A very remarkable cloud was observed vertically over the windward part of St. Vincent before the wind affected the island; and this appears to support Mr. Redfield's opinion, that the axis of the vortex is often inclined forwards, the upper current travelling somewhat faster than the lower. This cloud was, when first seen, of an olive green colour *, and of a very unusual and threatening appearance. A gentleman who perceived it, when a mile from his home, returned immediately, and had time to nail up his doors and windows before the wind began to blow violently; and to this precaution he attributed the safety of his house.

The centre of this hurricane probably passed over, or a little to the north of Barbadoes and St. Vincent. At the north extremity of this last island its effect was very destructive.

At New York the labouring people remark, that if the haze indicating a storm be seen over Staten Island (S. W.) the wind will come from the *north-east;* but if the haze be observed over the Jersey shore of the Hudson, (between west-north-west and north-west) then the storm will blow from the *south-east;* and it is said to be a seaman's remark, "that a north-wester will never remain long in debt to a south-easter." † Both of which observations bear out the idea of a gyratory motion of the wind in these storms, from right to left.

It has been constantly remarked, that not only boughs of trees, but heavy materials, such as slates and tiles, have been carried up into the air during West Indian hurricanes; and many curious circumstances have been related to which it is difficult to give credence, ‡ and yet which would be admitted as

* This was described to me on the spot by Mr. Simons, proprietor of the estate called the New Adelphi, who observed the cloud.

† American Journal of Science.

‡ "In the hurricane of 1675, one Mrs. Groome, endeavouring to go from her dwelling-house, in St. Philip's parish, Barbadoes, on the estate of Mr. Thomas Hardin, to an outhouse, was taken up by a whirlwind and carried through the air to a great distance, where she was found many hours afterwards, grasping the roots of a large tree newly blown down."—*Hughes's History of Barbadoes*, 1750, p. 36.

possible, if the aërial fluids in great hurricanes really revolve as they do in smaller whirlwinds. In our own climate we are accustomed to see very small progressive whirlwinds raising dust and small light particles, as they traverse a road; and larger ones are known to carry up water from the sea, and from rivers, as they pass over them. A very curious example will be found stated in Lyell's Geology, vol. iii. p. 32, 4th edition. In the Barbadoes hurricane of 1831, 1477 persons were returned killed in that island, besides those who afterwards died of wounds and bruises; and it was supposed that the returns did not include the whole. A return of loss of property, not including that of government or the shipping, amounted to 1,602,798*l.*

Building in hurricane countries.

But whether Mr. Redfield's opinions be established or not, there cannot be a doubt but that some difference of construction should be made in buildings, between countries subject to the most violent hurricanes, and countries which are not. Yet it is too often the practice, simply to place a roof on its walls, as is the custom in Europe, and to copy the details of construction from the modes adopted in England.

In places where buildings are subject to hurricanes, the whole of the roof should be fixed down to the wall-plate; the wall-plate should be fixed down to the wall; and the wall itself made strong enough to resist the current of air that may rush against the house. Where buildings are of wood, the frame-work should be tied into the ground, or into stone piers fixed in the ground.

In re-establishing the buildings blown down in 1831 in Barbadoes and St. Vincent, as far as I was employed in that duty, the wall-plates were in general tied down by irons, having L heads inverted, and built two feet down into the walls, with a nut screwed over the wall-plate; and in most of the angles a piece of hardwood timber, of a triangular section, placed in the corners, was strongly framed to one angle-tie above the wall-plate, and to another built into the wall near the foundation of the building.

It was observed that buildings having substantial partitions at short intervals withstood the blast, whilst others without them were blown down. Where large rooms therefore could not be divided, they were broken into portions by substantial projecting walls, serving as inside buttresses; and in general an

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elliptical arch was thrown across the room from one side to the other, on which one of the principal rafters was placed, and tied down at the ends. Most of the window-shutters of soldiers' barracks and storehouses, having no glass, were made to turn on their centres, on strong vertical pivots, one at top the other at the bottom of the shutter, and thus balanced they shut against rebates; for it was found, that where there had been shutters opening inwards, as in England, the wind bursting them open on the windward side, pressed and shut the leeward shutters; so that either the roof was carried off, or the leeward wall thrown down. Many buildings fell, owing to the joists of the floors for upper galleries, or verandahs, having one end let into the main wall of the building: these acted as so many levers, and upset the walls, when the galleries began to vibrate.

When reconstructed the joists ran parallel to the walls, their ends resting on arches, which were carried across the galleries from strong brick piers, to pilasters connected with the main wall, and every part of the galleries was tied down.

The brick-work was of the old English bond;* and it was grouted throughout, the bricks having been always saturated with water, which is a measure essential to strong building in tropical climates. In St. Vincent, the sand used for the mortar was selected with great care, and procured from crevices in the basaltic rocks. Four proportions of this sand to one of coral lime were always used; and it was found to have set so strongly, that on taking down a part within six weeks after it had been built, the bricks often broke before they could be separated.

One small building, reconstructed in a very exposed situation, was arched like a gunpowder-magazine, as kitchens so constructed had been found to stand uninjured.

An hospital, with much iron in its construction, and having iron ties reaching quite across it, so as to have the supports of one gallery bolted to the main building and to the opposite gallery, withstood the hurricane.

In re-establishing the roofs, diagonal bracing was inserted in most of the buildings to stiffen the rafters.

Copper gutters were found to have decayed after twenty years' use, and had

* This was done in consequence of reading a paper of Colonel Pasley's, which it would be desirable to reprint.

not lasted longer than the wooden shingles of the roofs to which they belonged; the copper sheets having worn into holes by the action of the heat and moisture of the climate, by which the metal was converted into the red oxide of copper. Iron nails decay very fast from the same cause. Latterly large slates have been substituted for wooden shingles for roofs, fixed down with two nails each; but it would be desirable to set them in some cement, which would not be deteriorated by the climate,* in order to prevent the wind from raising them and blowing them off. The following is a return of the expense incurred by the Royal Engineer Department in consequence of hurricanes:

West Indian Hurricane Estimates since 1830.

		£	s.	d.	£	s.	d.
Antigua—Hurricane of August, 1835.—	Ordnance	67	2	10			
	Barrack	917	8	10¾			
					984	11	8
Barbadoes—August 1831	Ordnance	4,021	16	9			
	Barrack	27,387	6	9			
					31,409	3	6
September 1835	Barrack				950	0	0
St. Kitts — August 1835	Ordnance	645	19	4			
	Barrack	302	16	2¼			
					948	15	6
Dominica — September 1834	Barrack				1,491	5	10
	Ordnance				1,351	18	8
Grenada — June 1831	Ordnance	34	3	11			
	Barrack	218	4	5			
					252	8	4
St. Lucia — August 1831	Barrack				879	16	7
St. Vincent—August 1831	Ordnance and Barrack				2,299	6	11
					£40,567	7	0

London,
17th Oct. 1837.

(Signed) F. G. ELLICOMBE,
Colonel, Royal Engineers.

The course of a fourth hurricane is laid down in Chart III., which is said to have been very disastrous to shipping. It was traced from the neighbourhood of St. Thomas, on the 29th September, 1830, to the North Atlantic; but the observations are defective, inasmuch as the bearings of the wind are only given

* Chalk, oil, and red-lead was used in pointing the joints of bomb-proof buildings at St. Vincent's, apparently with success. Compounds of oil and lead, as in paint, however, are decomposed by the climate: the oil evaporates, leaving the lead in a state of white carbonate, which is the white-lead of painters.

by a few ships; and though the line of its course passed over or near Bermuda, officers who were stationed there in 1830 do not recollect it.

The following are the data on which its course is founded, as published in the "American Journal of Science:"

"In lat. 20° 30′, long. 73°, the storm commenced on the 29th September, at 1 P.M., and continued until half-past 6 P.M., from N.E. to S.W. alternately.

"On the same day, in lat. 22° 46′, long. 65°, a hurricane.

"September 30th, at night, lat. 26° 7′, long. 66° 31′, *very heavy*, five hours and a half.

"1st October, lat. 30° 38′, long. 63°, severe at S.E. shifting to N.W.

"Ditto, lat. 33°, long. 66° 30′, severe gale or hurricane.

"Ditto, lat. 34° 9′, long. 66° 12′, hurricane at E.S.E..

"Ditto, lat. 35°, long. 68°, severe gale.

"Ditto, lat. 38°, long. 63°, hurricane.

"Ditto, lat. 38° 30′, long. 57°, severe gale.

"Ditto, lat. 40°, long. 61°, hurricane from nearly south; at 2 P.M. sudden and violent from the north.

"Ditto, lat. 40° 25′, long. 58° 24′, moderate gale, with heavy swell and cross sea.

"Ditto, lat. 41°, long. 55°, very severe.

Although no information relative to this hurricane could be procured from officers who were there in 1830, an occurrence was mentioned which seems to indicate a whirlwind on a small scale. In September 1830, a whale boat, on Smith's Island, in St. George's harbour, Bermuda, was lifted and carried 50 or 60 yards; and trees, along a narrow line, were blown down or injured; yet no severe wind was experienced elsewhere.

Hurricane, 3rd Sept. 1835.

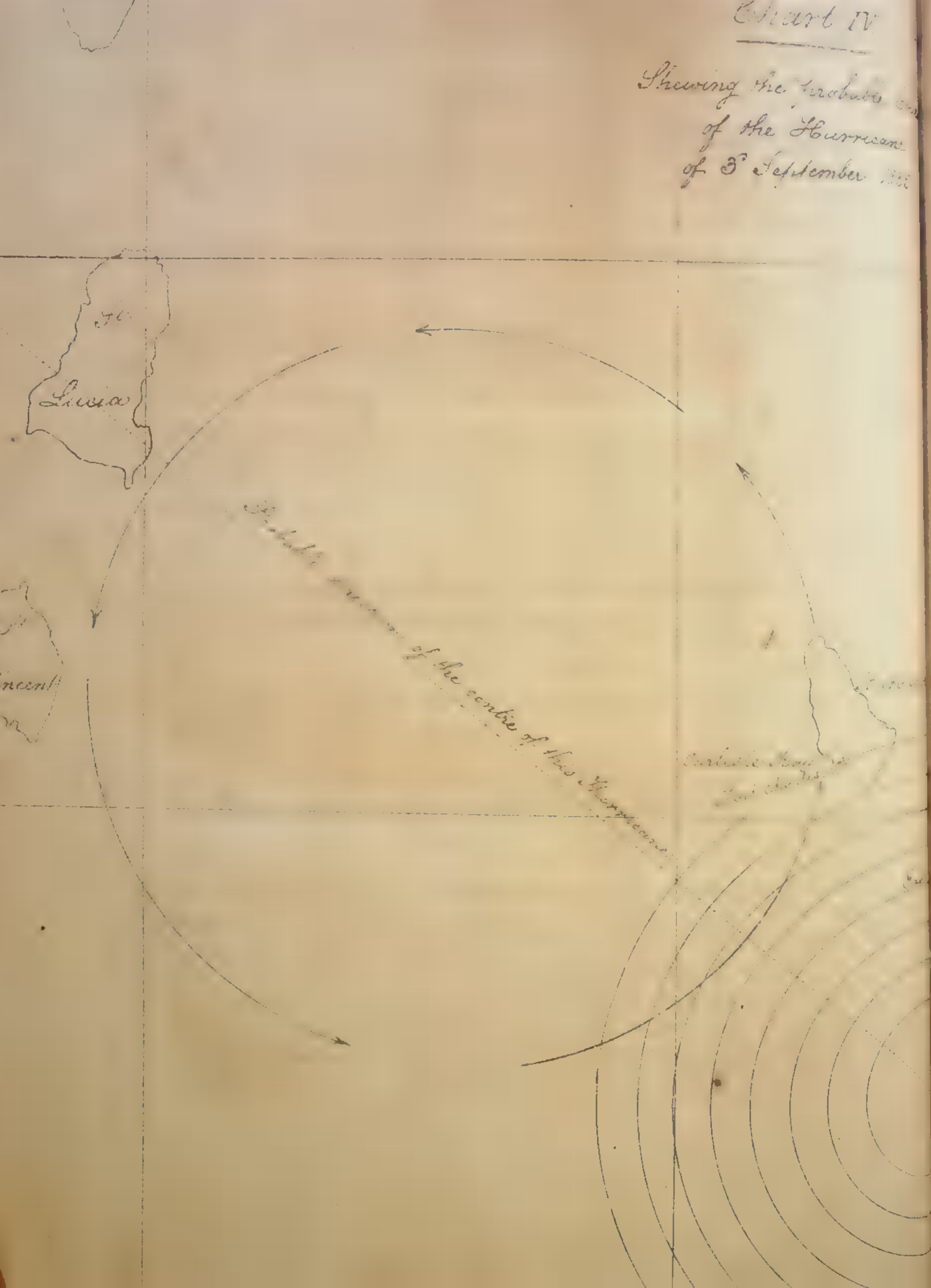
A hurricane, which occurred on the 3rd of September, 1835, at Barbadoes, seems further to confirm the idea that they are progressive whirlwinds.

This storm is said to have partaken in force of the character of a hurricane, although the wind did not veer into the quarter considered, at Barbadoes, as the hurricane quarter: it was consequently directed, as regards the buildings generally, upon the line where least precautionary resistance was opposed to its progress.*

This proves that the centres of their courses are usually, though not always, to the northward of that island.

At six o'clock in the morning of the 3rd of September, the weather was fine but more than usually close; and a ship was observed passing Carlisle Bay, with a press of sail, standing to the southward. It was afterwards ascertained that

* Sir C. F. Smith's Report.



the ship's barometers indicated an approaching storm before that hour. The workmen of the engineer department were put to work at the above hour upon a pier, constructing of timber in the bay.

About 9 A.M. a report was brought to the executive officer,* that the sea had suddenly risen to such a degree, that it threatened to destroy the new pier; yet at the moment there was less wind than usual.

The wind, however, soon began to blow hard, although it still came from the ordinary direction in which the trade-wind blows, (or somewhat to the northward of east) and it veered from that point by the east, until it blew into the bay just round a point on which Fort Charles is situated. The storm was slightly felt at St. Vincent, and more so at St. Lucia, which last island it is said to have reached soon after one o'clock. An inspection of Chart IV. will make this intelligible.

This hurricane cost the engineer department 950*l.* for damage done to buildings, though it was not a severe one.

In ordinary gales of wind on the English coast, the undulations of the waves proceed forwards at the rate of 12 miles an hour;† but those caused by hurricanes probably move very much faster: and if these storms are really rotatory ones, the undulations may be expected to precede them.

One of the dotted lines on Chart IV. is intended to represent the course of the centre of the storm, and a second line shows the direction in which it was probably cut by Carlisle Bay. By this line the wind would be east when about half the storm had passed, after which it would veer to the southward of east.

Most of the mail-boats (small decked schooners of about 50 tons) got under weigh and put to sea just before the storm, and some of them foundered. A large boat which broke from her moorings was found at St. Lucia.

A short time before this there had been a hurricane at Antigua and St. Kitts. At Antigua it happened on the 12th of August, 1835; the wind during the first part blowing from the north, and during the latter part from the south, with a calm of twenty minutes in the middle of it. From this account, the centre probably passed over Antigua.

* Capt. Tait, R.E., from whom this account was obtained. The ship was H.M.S Champion.

† As observed at the Brighton Chain-Pier, the distance between the piers being 255 feet. The height of the undulations may be seen by the marked piles. In a gale in 1836, which was not a severe one, the waves measured twelve feet high. In 1837, in a severe gale, Capt. Alderson, R.E. found the height about two feet more, and the rate of progress faster.

The barometer was observed to fall 1.4 inch; and the sympiesometer was much agitated, and fell proportionably.

Gusts. Trees were blown down, as if forming lanes, an effect which has been remarked in many other descriptions of hurricanes; and at their commencement the wind is constantly described as coming in gusts.*

Capper. In the year 1801, a work was published by the late Colonel James Capper, of the East India Company's service, on the "Winds and Monsoons."

In this work Colonel Capper states his conviction, that the hurricanes of the Eastern seas will be proved to be great whirlwinds; and he quotes an account of the destructive effects of several from "Orme's History of Hindostan." One of these storms destroyed a squadron of French ships of war, after they had taken Madras from the English, in 1746; and it is a fact deserving attention, that the most severe hurricanes recorded by Orme occurred on the Coromandel coast, in the same latitude as the Northern Antilles Islands, and that they happened in October.

Colonel Capper makes the following remark:—"It would not, perhaps, be a matter of great difficulty to ascertain the situation of a ship in a whirlwind, by observing the strength and changes of the wind. If the changes are sudden and the wind violent, in all probability the ship must be near the centre of the vortex of the whirlwind; whereas, if the wind blows a great length of time from the same point, and the changes are gradual, it may be reasonably supposed the ship is near the extremity of it."†

We are indebted to Mr. Redfield of New York for establishing, apparently beyond a doubt, that Colonel Capper's views were correct. This gentleman, being employed amongst the shipping in the great port of New York, has had the advantage of easy access to the reports of storms; and these it is necessary to obtain in great numbers, in order to be able to lay down the direction of the wind, at the same moment, at many different remote points.

The subject being both a new and an important one, I have been desirous, whilst bringing it to notice through the medium of this paper, to do so as clearly and also as fully as possible; and therefore I have been at some pains to collect information relative to the storms of the present year (1837), and to present the reports in the simplest form.

Such information as I can procure relative to the storms of the Indian Sea shall be added; for it is not the least interesting part of the subject, to inquire

* From a verbal statement of Major Barry, R.E., who was at the time at Antigua.

† Colonel Capper's work may still be got at Norrie's, Leadenhall-street.

whether the great storms of the Indian Ocean, and those which pass over our islands, are not also rotatory storms.

The Spey packet brought to England the account of two severe hurricanes in the West Indies in 1837. These have been traced, and are laid down on Charts V. and VI. The earlier of the two passed over Barbadoes on the morning of the 26th of July; at ten the same night it was at Martinique, by which hour it was all over at Barbadoes; at midnight on the 26th, and morning of the 27th, it reached Santa Cruz. By the 30th of August it reached the Gulf of Florida, where some vessels were wrecked by it, and many damaged; it then took a more northerly direction, being on the 1st of August at Jacksonville, in Florida.

From Jacksonville it passed over Savannah and Charleston, going in a direction to the eastward of north.

The other hurricane on Chart VI. was at Antigua on the 2nd of August; by the 5th and 6th it also was on the coasts of Georgia and Florida, crossed the line of the other hurricane, nearly meeting it; and it seems to have touched Pensacola on the 8th of August.

Barbadoes hurricane, 1837. The reports of these two storms are arranged in the order of their progress, and are as follow.

Extract from Lieutenant James's Private Journal:

"Barbadoes, July 26, A.M.—At two o'clock, light showers of rain, wind shifting from S. to N.W., the sky dark and gloomy, with flashes of lightning in the S.E. and S.W.: at four, calm, with a heavy swell rolling into the bay; lightning and thunder, sky assuming a blue-black appearance, with a red glare at the verge of the horizon; every flash of lightning was accompanied with *an unusual whizzing noise, like that of a red hot iron plunged in water:* at six the barometer fell rapidly, the sympiesometer much agitated and unsettled, and fell at length to 28 deg. 45 min.; hoisted in the boats, sent down top-gallant-masts, struck lower yards and topmasts, let go both bower anchors, veered out a long scope of cable on the moorings and both bowers: at 7.30, the hurricane burst on us in all its dreadful fury: at 8, it shifted from E.S.E. to S., and blew for half an hour, so that we could scarcely stand on the deck; made preparations for battening the hatches down and cutting away the masts; the sea came rolling into the bay like heavy breakers, the ship pitching deep, bowsprit and forecastle sometimes under water: the wind shifting to the W.S.W., at 9 the barometer began to rise, and to our great joy we observed a change in the sky for the better. As the haze cleared away, we counted twenty-one sail of merchantmen driven on shore, and perfect wrecks. Her Majesty's ship Gannet drove, with four anchors down, but fortunately brought up and rode out the gale. Her Majesty's steamer Alban went on shore, but in all proba-

The commencement.

Barbadoes hurricane, 1837.

bility will be got off. One brig foundered at her anchors, and sunk. Thank God we rode it out so well. The Spey, the Gannet, and Fortitude, merchant ship, were all that rode out the hurricane. The City of Kingston steamer put to sea, and returned next day.

"On the 30th of July the Spey left Barbadoes to run along the islands, and pick up the mails for England. Found that the hurricane had scarcely been felt at St. Lucia, but at Martinique several ships were wrecked."—*Times Newspaper.*

"The barque Clydesdale, from Barbadoes to Antigua, encountered a severe hurricane ten miles north of Barbadoes, on the 26th of July, 1837.

"Arrived the British schooner Emancipation, from Grenada. The captain states, that Grenada and the neighbouring islands had been visited by a violent gale on the 26th July, 1837."—*From the New York General Advertiser.*

"Our paper from St. Vincent's informs us, that the gale of the 26th of July was severely felt there; the wind being from the west and the south, with a heavy swell of the sea."—*From the Barbadian.*

"St. Lucia, 30th July, 1837.—We have experienced a severe gale from the north-west, which blew very violently for several hours."—*From Lloyd's Books.*

"Martinique suffered a severe gale on the 26th July, from the south-east. The brig Blayais went on shore, with forty-three persons on board, and only six were saved."—*From the Weekly Register.*

"The storm of the 26th July was felt severely at Martinique. The tempest raged there with great violence at 10 at night, at which hour all was calm at Barbadoes. The Blayais was driven on shore at St. Pierre, a harbour much exposed to the south-west. An American vessel was driven on shore at Fort Royal, which is an unusual occurrence, as that harbour has always been considered a safe anchorage in any weather."—*From the Barbadian.*

"One of the most violent gales of wind, which at this season are so alarming to these colonies, occurred on Wednesday last, 26th July, 1837. The wind blew from south-east all day, and about 8 in the evening a violent swell set in from the south-west, which occasioned a tremendous surf. The barque Jane Lockhart was obliged to slip her cables, and stand to sea. The Venus sloop was washed up into Kew-street. The sloop Dolphin, from St. Bartholomew's to Barbadoes, was forced back to this island, after having got within twelve miles of Barbadoes."—*From the Dominica Colonist.*

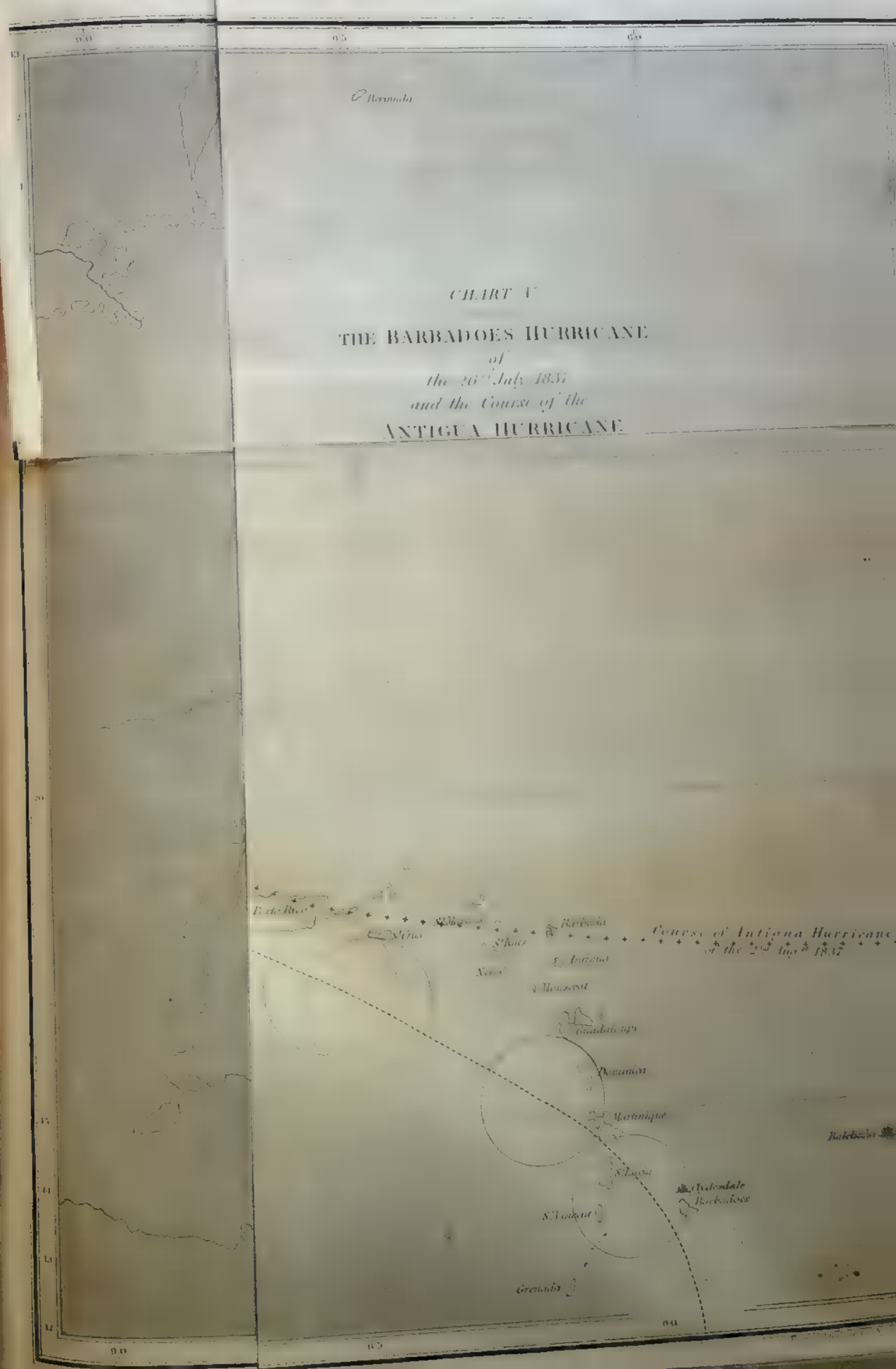
Copy of a MS. report at Lloyd's, dated St. Croix:

"About midnight on Wednesday, the 26th of July, it came on to blow smartly from the E.S.E., shifting by Thursday morning, the 27th July, to S.E., blowing a gale of wind until towards noon, when it began to moderate."—*Signed, Andrew Lang.*

"Le Navire Bonne Aimée à péri à porto Rico dans un coup de vent, 26, 27 Juillet, 1837."—*From the Port of Spain Gazette.*

"A Spanish brig was totally dismasted on the 28th of July, off St. Domingo, in a hurricane, and had to throw overboard a quantity of flour."—*American Paper.*

"St. Domingo, Aug. 13.—Two hurricanes have been recently experienced here, during



which the Edward (French ship) was wrecked in the outer roads, three of the crew drowned: three Haytain vessels were also lost on the coast, and only one man saved. Barbadoes hurricane, 1837.

"The gale on the 29th July, at Nassau, was from the E. and the E.S.E., as reported by the master of the sloop Humming Bird."—*Newfoundland Gazette.*

"There was a violent gale at Nassau, New Providence, from the E. and S.E., on the 29th July, which continued until 2 P.M. on Monday, the 31st July."—*New York Gen. Advertiser.*

Extract of a Letter from Lieut. Parsons, commanding Her Majesty's packet Sea-Gull, dated Falmouth Harbour, 18th Sept. 1837; addressed to Admiral Sir P. H. Durham:

H. M. Packet Sea-Gull.

"We arrived here on the 8th from Mexico and Havannah: we had the wind for twenty days from the E. and E.N.E., with four days calm. In coming through the Gulf of Florida, and in the narrow part of the channel, on the night of the 30th July, I experienced a very heavy gale of wind from the north-west, which increased on the morning of the 31st, with thick weather, lightning, and rain in torrents. At about 10 A.M. we discovered discoloured water on the lee-beam, having had no observation on the 30th. At this time the wind was west, which made the Bahama bank (where I judged we were) a lee-shore; and in carrying a press of sail to clear it, all of them were split and blown out of the bolt ropes: I was therefore under the necessity of anchoring in five fathoms water; and by the time I had veered out 100 fathoms of chain, the vessel's stern was in 4½ fathoms. I did not let go the other anchor, fearing she might founder, as the sea was making a fair breach, and rolling aft to the wheel on the quarter-deck; and if we parted, we had still a chance of getting into the old Bahama channel. With great difficulty we tried to get another jib and trysail set.

"On the morning of the 1st August the wind increased, and blew a perfect hurricane for about four hours, when it moderated a little, and veered to the south-west, which enabled us to bend another topsail. At noon we began to weigh, and in three hours we were able to make sail off the reef.

"The part of the bank on which I suppose we anchored is lat. 24° 40′ north, long. 79° 8′ west, and twelve miles south of Orange Keys. (Signed) "PARSONS."

"The barque Baltimore, from Havannah, experienced heavy gales from the westward, on the 31st July, which continued until the 1st of August. She was over the reef on the Bahama banks by the Cat Keys, and compelled to anchor and ride out the gale. When the weather cleared on the 2nd, she saw three vessels on the reef wrecked, but she was unable to lend them assistance."—*New York General Advertiser.*

"The barque Cossack, on the 1st August, encountered a violent gale forty miles south of St. Augustine. Met a ship, supposed to be the Emily, of Liverpool, dismasted, and making for a port."—*Ibid.*

"The ship Providence, on the 1st August, in lat. 29° 30′, experienced a heavy gale."—*Ibid.*

Extract of a letter from St. Simon's Island, lat. 31° 2′, long. 31° 28′:

"On the 1st and 2nd August we had a very severe gale here."—*From the New York General Advertiser.*

Barbadoes hurricane, 1837.

"The brig Monument (Fisher) experienced a severe gale on the 1st of August, off Cape Florida."—*From the New York General Advertiser.*

"The barque Josephine, on the 1st August, experienced a severe gale fron north-east, lat. 27° 50′, long. 79° 20′, and had some of her sails blown from the yards, though they were furled."—*From the Charleston Mercury.*

"The brig Moses, on the 1st August, off Cape Carnaveral, lat. 28° 16′, long. 80′ 24, experienced a severe hurricane, commencing at north-east and veering round to south, which hove the brig on her beam ends, and obliged her to cut away her mast. She was in fourteen feet water, and was saved by the wind coming from the south."—*Ibid.*

The schooner A. Brook, on the 2nd August, lat. 29° 38′, long. 80° 41′, experienced a severe gale of wind from E.N.E. to S.S.E. Lost her flying jib and split her mainsail."—*From the New York General Advertiser.*

"A severe gale of wind at Jacksonville, on Tuesday 1st August, which continued until Sunday, the 6th of August,* when it blew a hurricane from the north-east and south-east. Two government warehouses were blown down at Jacksonville, and the crops of cotton destroyed."—*From the National Intelligencer.*

"The barque Marblelead, of Boston, was lost on the western reef of the little Bahama bank on the 2nd August."—*From the Southern Patriot.*

"The brig Howell anchored on the little Bahama bank on the 2nd August, 1837. Obliged to cut away both masts to prevent her from going on shore in a violent gale."—*Ibid.*

"The Ida† experienced a severe gale in the Gulf on the 3rd August. All her sails were blown to pieces. The boats and twenty of the crew were washed overboard. The captain has brought her into port with five men."—*New York General Advertiser.*

"On the 26th July, the sympiesometer indicated the approaching storm more decidedly than the barometer."—*From the West Indian Newspaper.*

"The Georgia steam-packet left Charleston on Saturday, August 5th, 1837, in the morning, and arrived at Norfolk in the Chesapeake, on Monday the 7th August. Had rough weather and noth-east winds."—*From the New York General Advertiser.*

Greenock, Dec. 5, 1837.—Thursday 27th (26 P.M. *civil time*) July, in lat. 14° 28′ N., and long. 56° 12′ W., wind veered from E.N.E. to W.S.W., with a tremendous swell from the southward; the sky clouded, with thunder and lightning, and heavy rain, with all the appearance of hurricane of wind; furled all sails but the main-topsail; at 1 P.M. a heavy gust took the ship and laid the sail under water, which continued for the space of half an hour; at 3 P.M. the wind veered to the northward, and cleared up to the southward, but a very bad appearance to the south-west; had no barometer or symphiesometer; at 6 o'clock fine clear weather; made all sail for Demerara, where the Balclutha arrived on the 3rd August.

"WILLIAM MILREA."

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* This was owing to the second hurricane overtaking the first one.

† There are five ships named Ida. This is not the same ship which was in the third hurricane on the 17th August, 1837.

Antigua hurricane, 1837.

The Spey packet, which had been at anchor in Carlisle Bay, Barbadoes, during the hurricane of the 26th July, sailed from that island on the 30th for St. Thomas, delivering mails at the northern islands as she went along; and, as will be seen by her log, was very nearly sailing into the second hurricane.

Extract from the Log of H. M. Packet Spey, *in Civil Time*, Lieut. James, Commander.

Hours.	Wind.	Bar.	Ther.	Remarks.
				Tuesday, August 1, 1837.
A.M.		falling		A.M.—Moderate and cloudy, with light showers and hazy weather; barometer falling; landed the mails at Dominica. The Jane, Lockhart, of London, slipped and went to sea on the 26th, and returned to take in the rest of her cargo.
P.M.	S.W.			P.M.—Calm and sultry, the sky overcast with dark heavy clouds, exactly the same appearance they had before the hurricane came on at Barbadoes; employed in preparing for another blow; got all snug, and kept away to the S.W.; further off the land the better.
				Wednesday, August 2, 1837.
A.M.	S.E. to W.			A.M.—Heavy squalls, with lightning and thunder; heavy sea running; wind shifted from S.E. to W.
P.M.		rising		P.M.—Barometer rising; made more sail, and stood in for Guadaloupe; at 3 saw the land, ran in for Basseterre, and landed the mails in a heavy surf; at 5 bore away for Antigua.
				Thursday, August 3, 1837.
A.M.				At 5 A.M. close in with the land; observed the island had suffered lately, all the cocoa-nut trees were blown to pieces. The Montrose bark, of Liverpool, totally wrecked, with 300 hhds. of sugar on board, the day before, in a severe hurricane.
P.M.				P.M.—Made all sail for Montserrat.
				Friday, August 4, 1837.
A.M.				A.M.—Landed the mails, and found that there had been no hurricane felt on the 26th of July or the 2nd of August.
				Saturday, August 5, 1837.
A.M.				A.M.—Landed the mails at Nevis and St. Kitts; here the hurricane was most severely felt, The ship Julius, of London, full cargo, was wrecked on the 2nd, and so smashed to atoms, that there is hardly a vestige of her to be seen. The ship Michael, of London, on shore, hilged, part of her cargo saved, and discharging into the Robert, of London. The mail-boat Eleanor, with the Leeward mails on board, knocked to atoms; mails lost.
				Sunday, August 6, 1837.
A.M.				A.M.—Arrived at Tortola. Here the hurricane has destroyed the town and several plantations. One brig from St. John's, with a great number of small craft, total wrecks.
P.M.				P.M. at 2 30.—Came to an anchor in St. Thomas's harbour and landed the mails. Here the hurricane of the 2nd appeared to have concentrated all its power, force, and fury, for the harbour and town were a scene that baffles all description. Thirty-six ships and vessels totally wrecked all around the harbour, among which about a dozen had sunk or capsized at their anchors; some rode it out by cutting away their masts, and upwards of 100 seamen drowned; but what was very extraordinary, there was not one English vessel in the port. The harbour is so choked up with wreck and sunken vessels, that it is difficult to pick out a berth for a ship to anchor. The destructive powers of this hurricane will never be forgotten. Some houses were turned regularly bottom up. One large well-built house was carried by the force of the wind from off its foundation, and now stands upright in the middle of the street. The fort at the entrance of the harbour is levelled with the foundation, and the 24-pounders thrown down: it looks as if it had been battered to pieces by cannon-shot. In the midst of the hurricane shocks of earthquake were felt; and to complete this awful visitation, a fire broke out in the back stores of Messrs. Stubbs and Co. Heavy tiles were flying about from the tops of the shaking and trembling houses, killing and wounding many persons. One fine American ship, 500 tons, was driven on shore under the citadel, and in an hour nothing could be seen of her but a few timbers. Several fine merchant ships and brigs are at anchor, dismasted, with cargoes; and not a spar or rope for standing rigging to be had in the island. No place hitherto has suffered so much from a hurricane in all the West Indies as St. Thomas's. Thank God we escaped so well out of it. R. B. JAMES.

Antigua hurricane, 1837.

"JAMAICA, Aug. 13.—The Judith and Esther, arrived here from Cork, experienced a tremendous gale on the 1st inst. off Deceada, lat. 16°, long. 61°, for 24 hours, during which she was three times on her beam ends, and lost boats, part of bulwarks, and sails."

"On the 2nd of August, between 2 and 3 A.M. we had a smart gale from north, which crept gradually round by north-west, west, and south-west, until it died away at south-east."—*From the Antigua Herald of the 5th of August*, 1837.

"The barometer at Antigua in the gale of the 2nd August only sunk ·43, another sunk ·63."—*From the West Indian.*

"The brig Maria Jane upset and dismasted off Barbuda, in the storm of August 2, 1837."—*American Paper.*

"This morning between 3 and 4, the wind being north, a shower of rain fell. At half-past 6 A.M. the wind began to rise until 8, it then shifted to the north-north-west, and gradually increased *in gusts* until 10, during which time much rain fell. The wind then veered to the westward, and next to due south, then back to south-west,* and last backed to south again, from whence it blew steadily and with violence until 2 P.M. when it abated."—*From the Nevis Post Newspaper, August* 2, 1837.

"Early on Wednesday morning, the 2nd of August, the wind blew strong from the north, and indicated the forthcoming storm. At about 8 A.M. it veered to north-west, and shortly afterwards to west, during which time it blew a perfect gale, throwing a tremendous sea into the harbour, and threatening the destruction of every vessel."—*From the St. Christopher Gazette.*

"The mail-boat Eleonore, Captain Carter, wrecked to the eastward of the bay of Basseterre, St. Kitts, on the 2nd August, 1837."—*From the Kingston Chronicle, Jamaica.*

"At St. Bartholomew the storm commenced at north-east, and continued to increase with violence until 2 P.M."—*Barbadian Newspaper.*

Extract of a letter from the Dutch Island of St. Martin:

"A gale commenced about 9 A.M. and raged with great violence from 11 A.M. to 2 P.M., veering from east-north-east to north-west."—*From the Barbadian Newspaper.*

Extract of a letter from Lloyd's Correspondent, dated Santa Cruz:

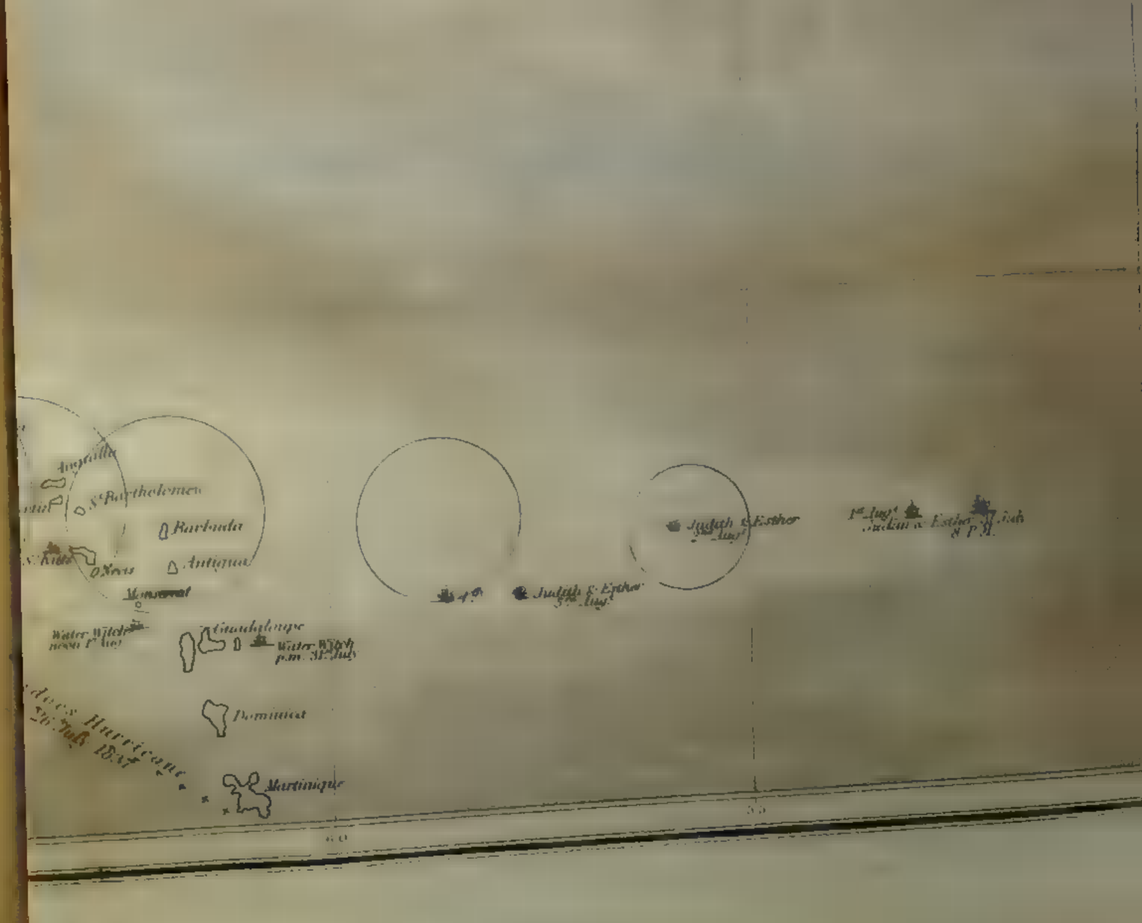
"On Monday, 31st July, 1837, the weather was moderate; several ships sailed on Tuesday, the 1st of August; in the evening the wind was north-east and the weather moderate. On Wednesday the 2nd, the wind during the night had shifted to the north; the weather looked squally, cloudy, and suspicious, and continued so during the forenoon; the wind shifted gradually to the north-north-west.

"At 1 P.M. the falling of the barometer, the appearance of the weather, and the increasing wind, left us no doubt of the approaching storm, and it came on from the north-west between 3 and 4 P.M. The mercury continued falling, and the gale increasing until

* "It is difficult to ascertain with certainty the direction of the wind while the storm continued."—*From the St. Thomas Times Newspaper, August* 5.

CHART VI

THE ANTIGUA HURRICANE
of
the 2nd August 1837
and the Course of the



half-past 6 P.M. when the wind became westerly. At 7 P.M. the mercury began slowly to ascend, but yet the storm increased in violence. At 8 P.M. it was blowing a hurricane from west-south-west to the south-west, coming in furious gusts until 10 P.M., when a certain decrease in their violence had taken place, which abatement continued until Thursday morning, the 3rd of August, when it blew a fresh gale from the south. Antigua hurricane, August 2, 1837.

(Signed) "ANDREW LANG."

"At Tortola the hurricane commenced at 3 P.M., and increased in violence until 9 P.M., when it began to abate."

"The brig Jane, of St. John's, N. B., was driven on shore during the gale on the 2nd of August."—*Tortola, August 6.*

Extract of a letter from Captain Newley, of the British brig Water Witch, from Liverpool to St. Thomas, and which left Liverpool, July 19, 1837.*

"Arrived off St. Thomas on the 2nd of August; morning squally, and the Water Witch was off St. John's, and standing for St. Thomas's, the wind north and north-north-west. Noon, shipping in the harbour visible; at 1 P.M. squalls violent; at 3 P.M. we had beat up within half a mile of the forts, when we could proceed no further for the violence of the squalls, and anchored in ten fathoms water; sent down top-gallant yards, &c.; did not suspect a hurricane. At 5 P.M. squalls ceased, and began a heavy gale of wind, at that time off the land. At 7 P.M. a hurricane beyond all description dreadful; the windlas capsized, and I could not slip my cables, ship driving until I was in twenty fathoms water; a calm then succeeded for about ten minutes, and then, in the most tremendous unearthly screech I ever heard, it recommenced from the south and south-west; I now considered it all over with us, for the wind was directly on shore, and the sea rose and ran mountains high. The foremast (though struck) and the gig were carried up some feet in the air, and the vessel drove again into twelve fathoms. We were obliged to steer her all night, and keep her head to wind, for when she got her bows to it she went down on her broadside. At 2 P.M. the gale abated somewhat, and the barometer rose an inch; at daylight, out of forty vessels, the Water Witch and one other were the only two not sunk, ashore, or capsized." Water Witch. Calm.

"Papers from Caraccas have been received to the 5th of September. They contain a detailed account of the hurricane at Puerto Rico, on the 2nd of August, which was equally disastrous in its effects with that at Barbadoes and the other West India islands. Fourteen Spanish vessels, nine foreign, of which however not one was English, and ten coasters, were entirely wrecked during the tempest."—*From the Hampshire Telegraph.*

Extract of a letter from the Harbour Master at Porto Rico to the Governor:

"At 4 P.M. on the 2nd of August, 1837, in consequence of having observed the barometer falling, I ordered all vessels in the harbour to prepare for stormy weather, although the fall of the barometer was not great.

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* Her track will be found on Chart VI.

Antigua hurricane, 1837.

"At 8 P.M. the mercury was at . . . . . 29·6
"At 9 P.M. . . . . 29·5 Wind at N.N.E. and strong.
"At 10 P.M. barometer . . . . . 29·4
"At 11 P.M. . . . . 29·3 Wind veering to E.
At this hour it began to blow in an alarming and furious degree until midnight; when the barometer stood at . . . . . 28·0 and every vessel sunk or ashore.
"At ½ p. 1 A.M. 3rd August, the barometer rose to 29·17
"At 4 A.M. the barometer stood at . . . . 29·5 Wind fell, and then veered to S.

"Thirty-three vessels were at anchor and all lost. From St. Bartholomew we have learned, that on the 2nd of August 250 buildings were destroyed."

"The Nile, American brig, foundered at sea August 4th, 1837, lat. 31° 30', lon. not known."

"The William IV. was lost at the island of Ramos, near the island of Taxando, Porto Rico."

"It blew a hurricane off Ragged Island on the 4th of August, 1837."

"A severe hurricane was experienced at Porto Plata (St. Domingo,) on the 3rd of August, which did considerable damage."—*New York Paper.*

"NASSAU, NEW PROVIDENCE, 6th Sept. 1837.—Since the storms which occurred here on the 29th of July and 5th of August, 1837, we have had no accounts from the out islands until within the last three or four days. These accounts are very distressing. It was the gale which began amongst them on August 4th which did the greatest damage. The sea rose on the south side of the great Bahama and washed away some low land. At St. Salvador, the storm was very severe, and several houses were blown down, as well as stock destroyed. At Long Island (more particularly on the north part of it) an unusual and destructive rise of the sea took place, and drowned a number of cattle. At Rum Key the loss was great indeed."—*From the Charleston Courier.*

"The Ulrica was dismasted off Hole-in-the-Wall on the 5th August, 1837."—*From the Charleston Mercury.*

"The brig Ann and Minerva, from Havannah to Corunna, on the 6th August, 1837, in lat. 30° 31', long. 73° 19',* during a severe gale from the south-east, was hove on her beam ends and compelled to cut away both masts."—*From the Southern Patriot.*

"The brig Bell, from Demerara to Nassau, in gales from the 4th to the 6th August. She experienced a succession of hurricanes from the north-west and south-west. On the 7th, in lat. 27° 40', long. 75° 50', spoke the Saratoga, and got a supply of bread and spars. On the 15th of August, in lat. 31° 21', long. 78° 57', met the Brilliant, Jamaica ship, bound for Liverpool, which supplied her with water and spars."

* This lat. and lon. places the ship beyond the verge of the storm, as I have marked it. The storm may have been more extended.

Extract of a Letter from Mr. Gleig, Commander of the ship Athol, from Havannah to Antwerp:

"Cowes, 15th Sept. 1837.

"SIR,—I sailed from Havannah on August 1st, with a favourable wind from the south-east, until the morning of the 5th,* when we were forced to shorten sail, with the wind from north-east. Towards evening we were compelled to heave-to, with a heavy sea going from the same direction, until the morning of the 6th, when about 9 o'clock the sea was perceived to be in a tremendous uproar, which was occasioned by the swell from the othe. direction. At 10 o'clock it fell away calm all at once, and in the course of 20 minutes the water was perceived, through the haze, to appear the same as heavy breakers: when about 10 hours 30 minutes, our breakers turned into a complete hurricane, which assumed its greatest strength in the course of an hour, and lasted until betwixt 4 and 5 in the afternoon, when it abated gradually. The direction of wind was in general from north to west, but at times it extended as far as south.

Ship Athol.

Calm.

"I remain, your most obedient servant,

(Signed) "GEORGE GLEIG, Master."

"To Lieut. Col. Reid, R.E."

"The brig William, from Portland to Matanzas, put into Charleston on the 5th of August, 1837. Off Abaco, experienced a severe gale from the north-east: lay-to; hove overboard all that was upon her decks. Finding she was driving towards the shore, cut away both lower masts and let go her anchors, with the full scope of cable. At 9 P.M., the wind shifted to the south-west, when she parted the starboard chain cables; then the crew shipped the other chain and tried for the nearest port. Fell in with the William Davison, from Jamaica to London, and received from the master a spar and a sail, for which he publicly thanks Captain Nares."—*Charleston Mercury.*

"Brig Pomeroy, off Abaco, in the gale on the 5th of August, 1837, lost her masts, and put into Wilmington."—*Ibid.*

"A severe gale of wind at Jacksonville, on the 1st of August, which continued until Sunday last, the 6th August, when it blew a hurricane from the north-east to south-east. Two government warehouses were blown down in Jacksonville, and the cotton crops destroyed."—*From the National Intelligencer.*

"The brig Opulence experienced a hurricane on the 5th August, 1837. Hole-in-the-wall bearing south-west forty miles distant; wind from south-east to north-east; lost top-masts, &c. &c."

"DARIEN, August 10.—During the last week we have been visited by a storm, which has not been equalled since that of the year 1824. The wind on Sunday last, in the morning, blew fresh from the N.E.; in the after part of the day it shifted round to S.E., when the rain began to fall in heavy torrents. The wind then rose very high, and began to blow with fearful violence, tearing up the oldest oaks and mulberry-trees in the place by the roots, while limbs and

* See her place on Chart VI.

Antigua hurricane, August 2, 1837.

branches of the different trees were flying in all directions. The water of the river then rose, and covered the rice plantations so completely, that they appeared to the eye to form part of the river. The rice, there is no doubt, will be greatly injured by the salt with which the water is impregnated. From the country, the accounts represent the cotton crops to be all but destroyed, and the corn broken down, and many houses unroofed. A letter from Jacksonville says, 'We have had the hurricane on a visit for two days. Houses innumerable have been destroyed, and two great stores have also been diminished. Our crops have shared a similar fate, especially corn, which is completely laid waste in the fields.' The vessels which had materially suffered from the hurricane are as follow:—The Bolivar, Richardson, drifted nine miles over the marsh, and left about six hundred yards from the bed of the river. Virginia in the same state. The Forester, after having dragged six miles over the marsh, left high and dry four hundred yards from the river. George and Mary, from Charleston, was lost; crew saved. The Favourite drifted over St. John's bar, and afterwards sank in Jacksonville harbour; cargo, United States' stores, lost. The Ann, after drifting six miles into the woods, was left seven hundred yards from the river. A schooner, with black bottom, on shore on Cumberland bank. A sloop on shore near Fernandi, with mast, &c. broken. Great apprehensions were entertained for the S. S. Mills, which left St. Augustine's on the 5th inst. with thirty passengers on board."—*Times Newspaper.*

Inundation by the sea.

"St. Mary's, August 13.—On the 5th we were visited with a very severe gale, which has done great injury to the crops and buildings. Our streets were completely inundated by the overflowing of the river, and persons walking were knee-deep in water. In the bay it was waist-deep, and it was not before long that the place was rendered impassable. Had the wind continued for two or three hours longer there could not have been a house left standing. The oldest inhabitant does not recollect a similar occurrence, and the buildings are all more or less injured. The damage here has been estimated at from 10,000 to 15,000 dollars. The cotton, as far as I have heard, is totally destroyed."

Schooner S. S. Mills.

"The schooner S. S. Mills sailed from St. Augustine's on Saturday, 5th August, 1837, for Charleston, with passengers; was overtaken by the hurricane on the 6th August, and capsized on attempting to cross the bar of St. Andrew's. One man only was saved on a spar."—*Charleston Mercury, 20th August*, 1837.

[From the Savannah Republican, Aug. 7.]

The two hurricanes.

"The Weather.—We have not for some time, particularly at this season of the year, been visited with a blow equal to that we have experienced for the last five days, and we are fearful that much injury has occurred to the shipping along the coast. Our city has suffered in the prostration of trees and fences. The tide on yesterday was over our wharves, and no doubt those who have planted on low lands on the river have suffered materially."—*Times Newspaper.*

"Savannah, August 15.—The heavy gale with which we have been visited has left us nearly desolate, and the houses left standing are much injured. All goods in the front of the stores are damaged, and many of the vessels in the harbour, after having dragged miles

up the river, are left high and dry upon the marsh. The schooner America was struck by the lightning, and her fore, royal, and main-top gallant-mast severely damaged; the decks ripped up, and her cargo set on fire, though not entirely consumed. The captain as he stood was stunned, and did not recover for an hour after. She was shortly to leave for New Orleans. Happily we have heard of no lives being lost, notwithstanding houses were frequently seen falling just on the eve of the tenants leaving them, while others were completely swept from their foundations by the water, which was from four to six feet deep in the streets. The cotton crop is totally lost; and it is considered by some who have seen several of the plantations, that ten bags will not be made round the country. I suppose the destruction by hurricane in this part of the country was never before so universal. Our cotton fields, which were good for a bag per acre, have been three feet deep in water, and our corn is utterly gone. It is impossible to estimate the damage done to the crops, buildings, trees, and fences; but it is my opinion that we shall scarcely recover in five years."—*Times Newspaper.*

Antigua hurricane, August 2, 1837.

"The schooner Erie, off Charleston Bar, the 6th August, 1837, at 3 P.M. The wind suddenly shifted to the south-east, and compelled her to stand to the south to prevent her going on shore. Passed two disabled vessels."—*From the Southern Patriot.*

"Brig Franklin, Captain Schofield, experienced a severe gale on the 6th August, 1837, off Doboy Island. She was compelled to scud, and make the north end of Cumberland Island. Struck three times in crossing the bar. Saw a schooner to leeward at the commencement of the storm. The schooner suddenly disappeared, but we soon saw her again, bottom upwards."—*From the New York General Advertiser.*

Extract of a Letter from St. Simon's Island:

The two hurricanes.

"On the 1st and 2nd of August, 1837, in lat. 31° 2′, long. 81° 28′, we had a very severe gale here; and on Sunday, the 6th August, it commenced blowing about noon; and between 3 and 5 o'clock it shifted from north-east to south-east, and became one of the most furious hurricanes we have had since 1834. It continued to blow until midnight, or 1 o'clock in the morning of the 7th, when it abated suddenly."

"The gale, which swept along the south coast, on the 7th of August, 1837, was felt in full force at Pensacola, lat. 30° 25′, long. 87° 29′. Almost all the vessels, except the ships of war, dragged and went ashore."—*New York Gazette.*

"New York, 23rd August, 1837.—During a violent gale at Pensacola, on the 8th inst., the brigs Alvira, Rondout, and Lion, were driven on shore, and much damage done to the shipping in port. Most of the small vessels were driven on shore."—*From Lloyd's List.*

In reading the logs, it is necessary to bear in mind, that most of those of merchant ships are still kept in *nautical time*, which begins at noon, and twelve hours before *civil time*. British ships of war now keep their logs by civil reckoning.

Antigua hurricane, August 2, 1837.

Extract from the Log-book of the Brig Water Witch, W. Newby, Commander, from Liverpool to St. Thomas, (kept by the Mate) made by Mr. Gilbert Ker, Consignee of the Vessel.

H.	K.	H.K.	Course.	Wind.	Remarks on board, Tuesday, August 1, 1837. Noon of 31st July, *civil time*.
2	....	....	West	E. by N.	P.M.—Fresh breezes and clear; people employed bending cables and shifting forctop-mast, and top-gallant studding-sails over.
4					
6					
8	5	....	W. ½ N.	Variable	At 5.30 made the island of Descada, bearing S.W. by S. distant about 6 leagues.
10	5				
12	6	....	Midnight		At dusk the land bore S.S.W.; midnight, squally with heavy
2	5	1	.....	E.N.E.	rain; in royals and all studding-sails.
4	6				A.M.—Steady breezes and cloudy; set do. sail; at daylight
6					made the island of Montserrat right a-head; set the jib and
8	....	....	W.N.W.	N.E.	trysail.
10	....	....	1st August	N.	Noon clear; rock Redonda bearing E.S.E., and Charleston
12					(Nevis) N.—Lat. obs. 18° 3′ N.
					Remarks on board, Wednesday, August 2, 1837. Noon of 1st August, *civil time*.
2	....	....	N.W. by W.	N.E.	P.M.—Fresh breezes and clear; people employed variously;
4					made the island of St. Kitts; in lower and all lee studding-
6					sails.
8	....	....	N.W. ½ W.		At 2 made the island of Saba.
10					At dusk in all studding-sails; Saba bearing N.N.E. and
12					Eustatia E.N.E.; at 8 in flying-jib and royals; midnight,
2					fresh breezes and cloudy; in top-gallant-sails.
4					A.M.—Do. weather.
6					At 7 made the island of St. John's, and shortly after that of
8					St. Thomas.
10					Noon, squally; double-reefed the topsails, and stowed the jib;
12					the town in sight.

Ship Judith and Esther.

"Cove of Cork, Dec. 14th, 1837.

"Sir,—Having received yours of the 7th instant, I haste to give you every information respecting the hurricane which I was in, on board of the brigantine Judith and Esther, of Cork, which vessel I was master of, and bound from Cork to Kingston, Jamaica.*

"I sailed from Cork on the 2nd of July, in the present year, for Jamaica, having carried a fair wind from the time of my departure up to the 1st of August, on which day I experienced a most dreadful hurricane, the following of which are the particulars:

"On the night of the 31st of July, at 8 P.M., in lat. 17° 19′ north, and long. 52° 10′ west, the wind blowing fresh from the north-east, and all possible sail set, *I observed a white appearance of a round form, nearly vertical,* and while looking stedfastly at it, *a sudden gust of wind carried away the topmast and lower studding-sails.* At 8.30 P.M. the atmosphere became very cloudy, and the wind increasing, we took in our small sails and took one reef in the topsail, *not observing at this time any swell* but what would have rose from such a breeze. The wind continued after this time quite steady from the north-east, and not increasing until the hour of 1 A.M. on the following morning, when the wind increased and the sea rose very fast, so

* See her place on Chart VI. being the easternmost vessel.

that it caused the vessel to labour hard. At 6.30 A.M. on the same day, close-reefed the top-sail, reefed the foresail and furled it, and close-reefed the mainsail; sent top-gallant-yards down, and housed the main-topmast; the sea at this time very high and regular from the north-east. Seven A.M. *the wind gradually increasing;* took in the mainsail and topsail, and let the vessel run under bare poles, all hands being of opinion that she would do better running than if hove-to; the sea at this time very high, and the vessel labouring and straining much, and shipping great quantities of water: the pumps being particularly attended to. At about 8 A.M. very heavy rain, and the wind increasing to a hurricane, so that it was impossible to hear each other speak on deck, or yet do anything for our safety. She broached-to, and was hove on her larboard beam ends, by a tremendous heavy sea, which after she righted we found took all the bulwarks nearly away on the larboard side. She had been for some time on her larboard beam ends before she rose, and when she did, the wind veered suddenly to the southward of east. After running a short time before the wind, she was hove again on her beam ends, which when she righted took all the bulwarks away on the other side except a few planks; she then became again manageable for about fifteen minutes, which time was about noon. After the short time she was manageable, it fell calm for about fifteen minutes, and the hurricane suddenly veered to about south, when we then gave up all hopes of safety. A sea, owing to the sudden shift of wind, had struck her on the star-board side, and hove the vessel the third time on her beam ends. *She had remained some time so,* the cabin nearly filled with water, and forecastle, (though as much precaution as possible taken against it;) all the boats (3), the cookhouse, water-casks, spare spars, sails, a quantity of spare rope, in fact, every thing of any value was gone; the mate, who was attending as well as possible to the wheel, was washed from it, the wheel was carried away, all the stanchions on the starboard side were broken, and every sail, except the mainsail, blown away into rags, though furled properly; the foretop, while on her beam ends, nearly smashed to pieces, when to our agreeable surprise we observed her again righten, and could not account for the manner in which we were saved, but through the powerful hand of an Almighty Protector. *For nearly an hour we could not observe each other, or any thing but merely the light; and, most astonishing, every one of our finger-nails turned quite black, and remained so nearly five weeks afterwards!** After she had righted, we observed the clouds break, which were from the commencement of the gale in a body, with heavy rain, the wind also abating a little; one hand managed to get below and procured a handspike, which we shipped as a tiller, and managed again to get her again before the sea, which was then running tremendously high; the pumps were again got at, and kept going. This time we considered about 3 P.M., the gale then began to abate, and the sea did not break so furiously, so that we managed to set a balance-reefed mainsail, and hove her to. The gale still abating, I went below, and found every article that could be damaged by salt water, damaged: the pumps still attended to; and we found she did not make any water except what got from the cabin and forecastle. At 6 P.M. the gale greatly abated and the sea fell fast. The appear-ance of the sky at this time was most remarkable, being of a deep red colour to the north, and looking very dark to the west, as if the gale was moving in that direction. At midnight the

Narrative of Mr. Seymour

Calm.

* A second letter on this subject follows this one.

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2	....	....	West	E. by N.	P.M.—Fresh breezes and clear; people employed bending cables and shifting foretop-mast, and top-gallant studding-sails over.
4					
6					
8	5	....	W. ½ N.	Variable	At 5.30 made the island of Descada, bearing S.W. by S. distant about 6 leagues.
10	5				
12	6	....	Midnight		At dusk the land bore S.S.W.; midnight, squally with heavy
2	5	1	.....	E.N.E.	rain; in royals and all studding-sails.
4	6				A.M.—Steady breezes and cloudy; set do. sail; at daylight
6					made the island of Montserrat right a-head; set the jib and
8	....	....	W.N.W.	N.E.	trysail.
10	....	....	1st August	N.	Noon clear; rock Redonda bearing E.S.E., and Charleston
12					(Nevis) N.—Lat. obs. 18° 3′ N.
					Remarks on board, Wednesday, August 2, 1837. Noon of 1st August, *civil time.*
2	....	....	N.W. by W.	N.E.	P.M.—Fresh breezes and clear; people employed variously;
4					made the island of St. Kitts; in lower and all lee studding-
6					sails.
8	....	....	N.W. ½ W.		At 2 made the island of Saba.
10					At dusk in all studding-sails; Saba bearing N.N.E. and
12					Eustatia E.N.E.; at 8 in flying-jib and royals; midnight,
2					fresh breezes and cloudy; in top-gallant-sails.
4					A.M.—Do weather.
6					At 7 made the island of St. John's, and shortly after that of
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10					Noon, squally; double-reefed the topsails, and stowed the jib;
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"On the night of the 31st of July, at 8 P.M., in lat. 17° 19′ north, and long. 52° 10′ west, the wind blowing fresh from the north-east, and all possible sail set, *I observed a white appearance of a round form, nearly vertical,* and while looking stedfastly at it, *a sudden gust of wind carried away the topmast and lower studding-sails.* At 8.30 P.M. the atmosphere became very cloudy, and the wind increasing, we took in our small sails and took one reef in the topsail, *not observing at this time any swell* but what would have rose from such a breeze. The wind continued after this time quite steady from the north-east, and not increasing until the hour of 1 A.M. on the following morning, when the wind increased and the sea rose very fast, so

* See her place on Chart VI. being the easternmost vessel.

that it caused the vessel to labour hard. At 6.30 A.M. on the same day, close-reefed the top-sail, reefed the foresail and furled it, and close-reefed the mainsail; sent top-gallant-yards down, and housed the main-topmast; the sea at this time very high and regular from the north-east. Seven A.M. *the wind gradually increasing;* took in the mainsail and topsail, and let the vessel run under bare poles, all hands being of opinion that she would do better running than if hove-to; the sea at this time very high, and the vessel labouring and straining much, and shipping great quantities of water: the pumps being particularly attended to. At about 8 A.M. very heavy rain, and the wind increasing to a hurricane, so that it was impossible to hear each other speak on deck, or yet do anything for our safety. She broached-to, and was hove on her larboard beam ends, by a tremendous heavy sea, which after she righted we found took all the bulwarks nearly away on the larboard side. She had been for some time on her larboard beam ends before she rose, and when she did, the wind veered suddenly to the southward of east. After running a short time before the wind, she was hove again on her beam ends, which when she righted took all the bulwarks away on the other side except a few planks; she then became again manageable for about fifteen minutes, which time was about noon. After the short time she was manageable, it fell calm for about fifteen minutes, and the hurricane suddenly veered to about south, when we then gave up all hopes of safety. A sea, owing to the sudden shift of wind, had struck her on the starboard side, and hove the vessel the third time on her beam ends. *She had remained some time so,* the cabin nearly filled with water, and forecastle, (though as much precaution as possible taken against it:) all the boats (3), the cookhouse, water-casks, spare spars, sails, a quantity of spare rope, in fact, every thing of any value was gone; the mate, who was attending as well as possible to the wheel, was washed from it, the wheel was carried away, all the stanchions on the starboard side were broken, and every sail, except the mainsail, blown away into rags, though furled properly; the foretop, while on her beam ends, nearly smashed to pieces, when to our agreeable surprise we observed her again righten, and could not account for the manner in which we were saved, but through the powerful hand of an Almighty Protector. *For nearly an hour we could not observe each other, or any thing but merely the light; and, most astonishing, every one of our finger-nails turned quite black, and remained so nearly five weeks afterwards!** After she had righted, we observed the clouds break, which were from the commencement of the gale in a body, with heavy rain, the wind also abating a little; one hand managed to get below and procured a handspike, which we shipped as a tiller, and managed again to get her again before the sea, which was then running tremendously high; the pumps were again got at, and kept going. This time we considered about 3 P.M., the gale then began to abate, and the sea did not break so furiously, so that we managed to set a balance-reefed mainsail, and hove her to. The gale still abating, I went below, and found every article that could be damaged by salt water, damaged: the pumps still attended to; and we found she did not make any water except what got from the cabin and forecastle. At 6 P.M. the gale greatly abated and the sea fell fast. The appearance of the sky at this time was most remarkable, being of a deep red colour to the north, and looking very dark to the west, as if the gale was moving in that direction. At midnight the

Narrative of Mr. Seymour

Calm.

* A second letter on this subject follows this one.

Antigua hurricane, August 2, 1837.

gale considerably abated and the weather appeared much better, the vessel not making any water. At 4 A.M. on the following morning, being the 2nd of August, the weather appeared as before the gale (a steady breeze from north-east), the atmosphere at this time being a dark red, and the clouds *not moving*. We at this time bent the second topsail and ran under it single-reefed, and a close-reefed mainsail. At 10 A.M. on the same day, the wind remaining quite steady, ran under a whole topsail and single-reefed mainsail; the crew being quite exhausted, I gave them the remainder part of the day for rest.

"*Answers to your printed questions.*

"1. Latitude of Judith and Esther, 17° 19′ north, long. 59° 10′ west.

Calm.

"2. 31st July, 1st August, and 2nd ditto.

"3. Wind at north-east, and veered easterly to south or south-south-west.

"4. A *calm* in the centre of the storm for fifteen minutes.

"5. No swell preceded the storm.

"6. The barometer was broken; but by the barque Laidmans, of Liverpool, Capt. Hughes, which arrived in Kingston four days after me, her barometer (in the lat. and lon. in which I experienced the gale) was very unsteady, rising and falling during three days, and a very heavy sea running though not an increase of wind.

"7. The weather for two days before the storm was cloudy, but not much way on the clouds though a fresh breeze night and day.

"8. *See* 6.

"9. Most of the particulars of the log are herein mentioned.

"10. I cannot state any other facts than those mentioned, except those of our sufferings, which were very great, more so than any person could imagine.

"11. All the within particulars are well authenticated, which will be seen by the protest now in London.

"I trust every information you require is here; and if the track of the Judith and Esther be required, I shall send you an abstract; *it is really worthy of notice.*

"(Signed) "WILLIAM SEYMOUR."

"To Lieut. Col. Wm. Reid, R.E."

On receiving Mr. Seymour's first letter, I wrote for an explanation on certain parts of it, and the following is his answer:

"Cove of Cork, January 2nd, 1838.

"Respecting the gust of wind which first alarmed us on the night commencing the hurricane? It came from a north-east direction, and remained so without turning until the time mentioned in my last to you.

"Secondly, as to our holding on when the vessel lay on her beam ends the third time?

"The third time the vessel had been on her beam ends some of the crew were in the main rigging, and the others standing on the weather side of the companion, holding on the weather rail.

"Thirdly, as to the cause of not being able to see each other?

"The cause of this cannot well tell; but while running before she was hove the third

time on her beam ends; and while on her beam ends the atmosphere had quite a different appearance; darker, but not so dark that (I should imagine) would hinder one from seeing the other, or from seeing a greater distance, were it not that our eyes were affected. It was about this time our finger-nails had turned black; and whether it was from the firm grasp we had on the rigging or rails I cannot tell, but my opinion is, that the whole was caused by an *electric* body in the element. *Every one of the crew were affected in the same way.* Antigua hurricane, August 2, 1837.

"I trust all information you may require is here: any further I will be most happy to give, as I will be at home for some time.

"I have the honour to be, Sir, your most obedient servant,

"To Lieut. Colonel Wm. Reid, R. E." "W. SEYMOUR."

Whether the hurricane, which reached Antigua on the morning of the 2nd of August, 1837, originated at the place of the Judith and Esther brigantine, at 8 P.M. on the 31st of July, or not, I shall not attempt to decide.

By comparing Charts V. and VI., and the dates of the reports, it will be seen, that these two hurricanes nearly met, and that their paths probably crossed each other. The atmospheric currents formed by the first one, on Chart V., may have been the cause of the second passing on over Florida towards Pensacola.

A clue to variable winds.

These two storms, and their courses, would seem to point at an explanation of the variable winds.

Hurricane, middle of August, 1837.

Chart VII. is another hurricane of 1837, of great extent, and which swept over about 10 degrees of latitude and longitude. Its nature and violence will best be understood by reading the extracts made from papers found at Lloyd's, in London, and from the documents furnished by owners and commanders of ships which suffered from it.

These documents are printed in detail, like the preceding ones, that those who choose to read them may be furnished with the means of forming their own conclusions.

Most of the ships placed on this chart were drifting with the Gulf-stream during the storm, at a time when no observations could be got. Their actual places, therefore, during the storm, cannot be ascertained with exactness; but the evidence from the reports leaves little doubt but that this great storm, like the others, was rotatory and progressive. The following are the documents:

"St. Augustine, 19th August, 1837.—On Tuesday, the 15th August, we were visited by a third gale of wind, of equal severity with the two which preceded it, and which continued until the afternoon of Friday, 18th August, when it ceased."—*American Newspaper.*

Hurricane, middle of August, 1837.

The French brig Yolof, from Havannah to Havre, experienced a violent gale on the 14th August. (This ship's log has been obtained from France, and will be found further on.)

"The schooner James Busick, sailed from Norfolk, U. S., for the West Indies, but returned, being damaged in a severe gale on the 14th August, which continued with violence for thirty-six hours."—*American Newspaper.*

"A severe gale at Turk's Island on the 15th August."—*From Lloyd's List.*

Calypso.

The Calypso, Captain Wilkinson, left Jamaica on the 1st August; and on the 15th, in lat. 26° 47′, long. 75° 5′, the gale overtook her, the wind coming from about the east-north-east, and continued increasing to a hurricane. At one time the ship lying-to, with a tarpauling in the main rigging.

On the 17th a sea stove the fore-scuttle, and the water poured down in torrents. The ship was under water up to the beams, and all attempts to keep her before the wind were unsuccessful. Several attempts were made to cut away her mizenmast; but whilst in the act, the ship turned over, and the crew, clinging to the weather-rigging, got upon her bottom, the lower yard-arms going under water. The carpenter had kept hold of his axe; and from the ship's side, or bottom, he, the captain, and the crew, actively cut away the weather-rigging, the sea breaking over them all the time: the rigging cut, all the masts broke off at the level of the deck, and, as the vessel gradually righted, the crew got on board again.

The boats were gone, the hatches stove in, and all the pumps broken. But since this was written, I have received from Captain Wilkinson his own account, which is this:

Narrative of Capt. Wilkinson, Master of the Calypso, in the storm of the middle of August, 1837.

"On the 15th August, at noon, the Calypso was, by observation, in lat. 26° 47′ north, and long. 75° 5′ west; the wind was from the eastward, about east-north-east; she had royals and fore-topmast-studding-sail set: shortly after, we got a heavy swell from the north-eastward, and the wind freshened gradually till 9 o'clock, when only the double-reefed top-sails, reefed foresail and mizen, could be carried. During the night the wind increased, and daylight (the moon about full) found the vessel under a close-reefed main-topsail, with royal and top-gallant-yards on deck, and prepared for a gale of wind. At 10 A.M. the wind about north-east, the lee-rail under water, and the masts bending like canes; got a tarpaulin on the main rigging, and took the main-topsail in; the ship labouring much, obliged main and bilge-pumps to be kept constantly going. At 6 P.M. the wind north-west, I should think

the lat. would be about 27°, and long. 77°. At midnight the wind was west, when a sea took the quarter-boat away. At day-dawn, or rather I should have said the time when the day would have dawned, the wind was south-west, and a sea stove the fore-scuttle; all attempts to stop this leak were useless, for when the ship pitched the scuttle was considerably under water: I then had the gaskets and lines cut from the reefed foresail, which blew away; a new fore-topmast-studding-sail was got up and down the fo[illegible]

Hurricane, middle of August, 1837.

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Hurricane, middle of August, 1837.

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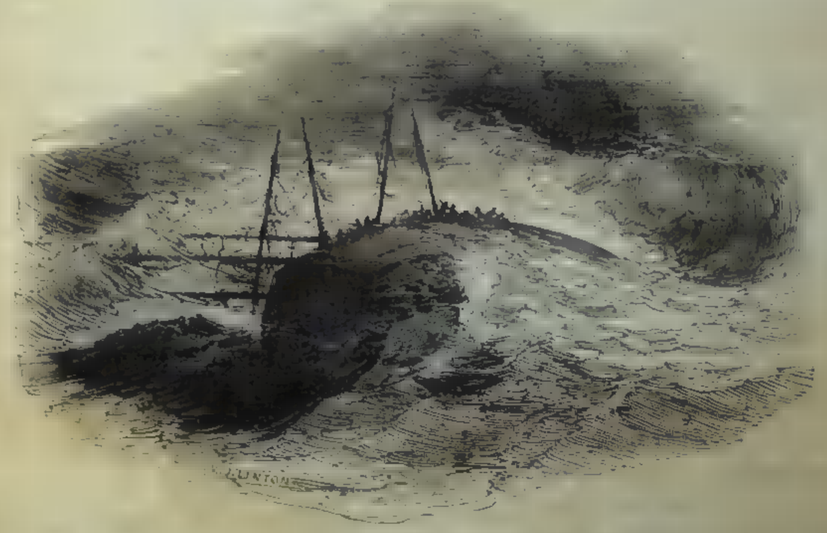


"She then righted very slowly. On getting on board again, I found the three masts had gone close off by the deck: the boats were gone, the main hatches stove in, the planks of the deck had started in many places, the water was up to the beams, and the puncheons of rum sending about the hold with great violence; the starboard gunwale was about a foot from the level of the sea, and the larboard about five feet; the main and mizenmasts were held on the starboard side by the lee-rigging, and the foremast was kept from floating from the starboard side by the stay. The sea was breaking over the ship as it would have done over a log. You will, perhaps, say it could not have been worse, and any lives spared to tell the

Hurricane, middle of August, 1837.

tale. I assure you, Sir, it was worse; and by Divine Providence, every man was suffered to walk from that ship to the quay at Wilmington, although the main and bilge-pumps were broken! The wind, from about noon of the 16th till about 10, or noon of the 17th, blew with nearly the same violence. There was no lull; neither did it fly from one quarter of the compass to the other, but backed from east-north-east to south-west, and then died away gradually. On Sunday, while beating off Rum Kay, the wind was variable and squally. On Monday, in lat. 24° 40′, long. 74° 45′, had fine steady winds from the eastward. Tuesday I have described. I had no barometer; but from the appearance of the weather on Monday and Tuesday morning, I did not apprehend we should have had bad weather.

"We shall now return from noticing the winds and weather, to see the Calypso safely anchored. After fishing the pumps, and getting them made air-tight, by putting candles and winding new canvas round, they were set to work, notwithstanding the seas breaking constantly over. The wreck of the masts was cleared, about sixty puncheons of rum stove, and the men remained night and day at the pumps, till Monday the 21st," when the water in the hold having decreased to nine feet, a spare spar was lashed to the paul-bolts for a jury-foremast, and a topsail set on it, the wind being then southerly. On Tuesday, the spritsail-yard was turned into a jury-mizenmast, and an old foresail set on it, that being the only sail, except the jib of the sparesail, that was not entirely destroyed. On Wednesday, got the pumps to suck, and set the jib forward: there being only two-thirds of a puncheon of water, two bags of damaged bread, and a barrel of pork, but no cooking apparatus on board, were obliged to go on an allowance of one pint of water each per day. The condition the men now were in was indeed very bad; they were worn down with fatigue, had lost all their clothes and bedding, and were *covered with boils*. On Friday, shortened the allowance of water to half a pint each per day, and remained in that condition till the 30th, during the days, under a scorching sun, and at night laying on deck. On the 30th, in lat. 32° 25′, and long. about 78½° W., we fell in with the American brig Rupert, from Havannah to New York: the generous captain immediately sent a puncheon of water, some fruit, and many little luxuries, for which I shall ever feel grateful. This was the third vessel we had spoken since the hurricane, but the only one that assisted us. The first had had his deck swept, and could spare nothing; the second was an American brig, that we fell in with at night, and hailed, telling him our distress: he asked if we could remain on board till daylight: and when told that I only wanted provision and water, he surlily asked, 'What ship is that? where are you from? where are you bound to then? what's your longitude?' When all his questions were answered, he hauled his wind, and at day-dawn in the morning could just be seen on the horizon.* *On the 31st of August* we sighted the land, about thirty miles to the southward of Cape Fear, but *the wind coming more from the eastward*, had to bring up in five fathoms water. During the night *the wind increased*, but fortunately *backed into the northward* (which was off the land,) and at noon on the following day *blew a very heavy gale of wind*,

* It is to be hoped that we shall yet trace this brig, and find out the captain's name. Such conduct merits the severest censure; and it is for the interest of all commercial nations to find this fellow out, and to expose him.

Hurricane, middle of August, 1837.

and continued until the *morning of the 2nd*, when it *backed to the west-north-west*, and moderated: we then slipped the cable, and sailed along the land for Baldhead lighthouse. At noon we got a pilot on board, and anchored once more in port. We were kindly received by the good people at Smithville and Wilmington, who complained bitterly of the late storm, for many of their houses were unroofed, and trees blown down.

(Signed) "GILBERT WILKINSON."

"To Lieut.-Col. Reid, R.E."

Two paintings of the ship have been made by the marine-painter, Mr. Huggins, under the direction of the master, Captain Wilkinson; and Mr. Huggins has here reduced sketches from his painting for this article. The first shows the crew on the ship's bottom cutting the weather-rigging, and is placed where that act is described.

The other is the Calypso, under jury-masts, and the crew bringing their ship into Wilmington. The "*shifting of the wind to the eastward, and its increasing*," will be again adverted to, in illustration of our subject.

"The brig Mary, Sharp, dismasted and lost her rudder on the 16th August, lat. 27° 30′, long. 73° 50′."

"The brig Cumberland put into Nassau, having experienced a hurricane on the 15th August."—*Lloyd's List.*

"The Mary, Sharp, from New Orleans to Barbadoes, was abandoned on the 5th September, lat. 32°, long. 80°, having been dismasted and thrown on her beam ends, with six feet water in her hold, in a gale on the 16th August, in lat. 27° 30′, long. 73° 53′."

Hurricane, middle of August, 1837.

"The Neptune, from Jamaica to London, was dismasted in this storm."

"The Jennet, Gibson, from Honduras to London was capsized in a gale on the 21st August. On the 3rd September, the crew arrived at Rhode Island."

"The Emerald saw the Rosebud, of Glasgow, on the 23rd August, in lat. 34°, long. 75°, a wreck; stood for her, and found her *derelict*."—*Lloyd's List.*

"The Duke of Manchester was thrown on her beam ends, and lost her mainmast in a gale on the 18th and 19th August, lat. 32°, long. 77°."—*Ibid.*

"The brig Yankee, on the 16th August, in lat. 24° 30′, long. 70° 30′, experienced a severe gale of wind from north-east to south-south-west, which lasted until the 20th. Lost her foresail, main-topsail, &c. &c."—*New York General Advertiser.*

"The packet ship Sheridan, Russell, arrived at New York, on the 28th August, from Liverpool. On the 22nd August, in lat. 39° 45′, long, 68° 33′, experienced a hurricane, which took away the fore and main-topsails (double reefed) from the yards entirely, leaving nothing but the bolt-rope standing."

"PHILADELPHIA, Aug. 19.—The Mecklenburg brig Harmonie, Galle, from New York for Alexandria, was driven on shore fifty miles to the southward of the Capes on Saturday night last in the gale; the captain has come to town for assistance, and states that the vessel is perfectly tight, and can be got off without much damage."

"NEW YORK, Aug. 31.—The Hindley, Turner, from Laguna for Liverpool, which was off Sandy Hook on the 16th inst. dismasted, has been brought up to this port; the three lower masts have been replaced without discharging, and it is expected she will be able in a fortnight to proceed."

"Sept. 8.—The barque Wanstead arrived here from London, experienced on the 23rd August, in lat. 43° 34′, long. 54° 20′, a severe gale of wind; lost boat, stove bulwarks, and washed seven men and the captain overboard, and succeeded in getting them on board again."

"The Rosebud, Dick, from Havannah to London, was capsized and dismasted on the 18th August, in lat. 34°, long. 74°; fallen in with by the General Sumpter, Bonnet, which attempted to tow her into the Chesapeake."—*Lloyd's List.*

Extract from an American newspaper, dated Wilmington, August 25:

"On the afternoon of Friday, the 18th, the wind shifted to the north-east, and rain began to pour heavily. Before midnight the storm increased, threatening ruin; and daylight revealed to us uprooted trees, and our streets washed into gullies, roads obstructed, and bridges carried away. [Then follow the details of injury done to buildings.] The embankments of the sea it is said have given way, and that two new inlets are formed opposite M'Rae's, of Peden Sound. The tide rose six feet higher than usual."—*From the Charleston Mercury.*

"NEWBOURNE, N. C., Aug. 25.—A severe gale commenced on Friday, the 18th, at midnight, and continued until Sunday, 20th, at daybreak."—*Ibid.*

"There was a severe gale at Charleston on the 17th, 18th, and 19th of August."—*New York Daily Express.*

"The William Thompson, which arrived yesterday from Jamaica, having sailed on the 29th July, and come by the windward passage. She encountered a hurricane in lat. 38°, long. 60°, on the 21st and 22nd of August, 1837."—*Lloyd's List, 19th Sept.*

Hurricane, middle of August, 1837.

"The Lady Katharine, Barham, from Jamaica; in a hurricane 16th, 17th, 18th August, 1837, in lat. 29°, long. 77°."

"The Brilliant, from Jamaica, experienced a violent hurricane on the 18th August, 1837, 120 miles south of Cape Hatteras, which lasted to the 21st."—*Ibid, 18th Sept.*

"The Westchester, from Havannah, experienced a heavy gale from the north-east, on the 18th and on the 20th, in lat. 32°, long. 74°."

"The James Ray, from Jamaica, sailed 1st August, and came the Gulf passage; experienced dreadful weather, particularly on the 16th and 19th."—*Ibid, 15th August.*

"The Maria, from Honduras to London, on the 20th of August, in lat. 33°, long. 74°, capsized. A boat's crew picked up by the Hogarth, from New Orleans, bound to New York."—*Ibid.*

"The Argus, on the 20th and 21st of August, experienced a heavy gale from east, and suffered damage."—*New York General Advertiser.*

"The Mecklenburgh brig, Harmonia, was run on shore fifty miles southward of the Cape, on Saturday night last, 19th August, in the gales."—*Ibid.*

"The ship Napier, from Liverpool, 19th August, off Cape Henry, experienced a heavy gale from east and east-north-east."—*Ibid.*

"Captain Robinson, of the Maria, was saved in his boat, with his crew. The Maria was capsized on the 20th August."—*Ibid.*

"LIVERPOOL, August 4.—The Experiment, arrived here from Nassau, experienced a hurricane on the 20th of August, and lost sails, &c. There were two severe gales at Nassau previous to the 12th of August, and several vessels lost."

"The barque St. Helena, on the 18th and 19th August, experienced heavy gales from the north-east and north. At 7 P. M. on the 19th, lost the close-reefed main-topsail, lying-to. Wind shifted to north-west, and blew a hurricane for twenty-two hours, during which time she lay-to under five yards of canvas in the mizen rigging; rail under water part of the time."—*Ibid.*

"The steam-packet Columbia, from New York to Charleston, experienced a severe gale on the 20th August, from east to north-west."—*Ibid.*

"The Powhatam, Chase, from Malta and Gibraltar to New York, on the 22nd August, lat. 40°, long. 67° 30′, experienced a tremendous hurricane from east-south-east to north, and lost both top-gallant-masts."—*Ibid.*

"PHILADELPHIA, August 30.—Arrived the ship Ellen Mar, from Cronstadt, and the Citizen, from New Orleans, in distress. On the 18th, had experienced a hurricane; on the 22nd, picked up Captain Tilley and the crew of the Ida, from Jamaica, bound to London."

"The barque Chief, Elridge, from Charleston for Boston, suffered severely in a gale on the 19th August, off Frying-pan shoals. On the 21st August spoke the Duke of Manchester, lat. 34° 12′, long. 74°, main and mizenmast gone."—*Ibid.*

Hurricane, middle of August, 1837.

"The brig Pensacola, on 18th August, lat. 31°, long. 79° 30′, encountered a heavy gale; carried away tiller and foremast."—*New York General Advertiser.*

"Express Mail.—A third storm has visited the Floridine coast, but the details are not yet known."—*Ibid.*

"A severe gale was experienced at Washington, Edenton, North Carolina, on the 18th August. Great damage has been done, and several vessels have been lost; one of them, with the crew, on the bar of Washington."—*Ibid, 29th August.*

"The Oglethorpe, on the 13th August, experienced a violent gale from the north-west. (Lat. not given.")—*Ibid.*

"Captain Robinson and crew of the Maria, of Hull, were picked up by the Hogarth."

"The brig Vincennes, from Teneriffe to New York, in lat. 35° 30′, long. 65° 40′, on the 21st August, experienced a heavy gale from south-south-west."—*Ibid.*

"The brig Delos, Smith, from Leghorn and Gibraltar, on the 21st August, in lat. 37° 40′, long. 66° 30′, had a gale from the south and south-east; on the 22nd she had moderate weather."—*Ibid.*

Sophia.

An Account of Part of the Voyage of the Sophia, J. Barclay, Master, from Jamaica to London, in August 1837.—In *Nautical Time*.

Hour.	Wind.	Bar.	Ther.	Remarks.
				Tuesday, August 4, 1837.*
Noon	S.W.	set fair		Wind S.W.; a fine steady breeze, with a peculiar haze round the horizon; the sky heavy to the northward, and clouds meeting it from S.W.: at noon doubled Cape Maize; *met a heavy sea from the northward:* the water covered with dried wood, evidently washed off the neighbouring bushes very recently; barometer standing at set fair.
				Friday, August 5. 1837.
P.M.	S.W.	set fair		Wind S.W.; steady breeze; sun obscured by thick haze; head sea making the ship plunge much; obliged to shorten sail and lower the topsails on the caps; at 6 P.M. spoke an American schooner from Port-au-Prince, apparently prepared for and anticipating a breeze; at midnight reefed the foresail and close reefed the topsails; squally; barometer as yesterday; at daylight made all sail, the sea having fallen considerably; at noon, wind S.S.W. fine breeze; the sun partially obscured by *reddish haze;* latitude observed 21° 52′, longitude p. chronometer 74° 10′ 30″ W.; barometer stationary set fair.
	S.S.W.			
				Saturday, August 6, 1837.
P.M.	S.W.	set fair		Wind S.W. with the same appearance; at 2 P.M. saw Castle Island N.N.W. about 4 leagues; at 3 perceived two vessels on shore their beam ends, with a signal of distress flying, and tents on the beach; proved to be two Nassau wreckers, cast away the day before in a violent hurricane from the northward, which they gave a terrific account of. From this date to the 13th inst. fine weather, with the wind from N.E. to E.
	N.E. to E.			
				Sunday, August 13, 1837.
A.M.	E.	fair		Wind E.; squally with rain; A.M. dark and cloudy with thunder and lightning; at noon observed in lat. 27° 20′, long. p. chronometer 74° 57′ 20″; barometer at fair.
				Monday, August 14, 1837.
A.M.	E.	fair		Wind E.; moderate; observed a long swell coming from the southward and eastward; A.M. squally; made and shortened sail as necessary; at noon, dark cloudy weather; latitude by indifferent observation 28° 38′, long. 74° 50′ 15″; barometer at fair.

* See Charts VI. and VII.

Account of the Voyage of the Sophia—*continued.*

Hurricane, middle of August, 1837.

Ship Sophia.

Hour.	Wind.	Bar.	Ther.	Remarks.
				Tuesday, August 15, 1837.
..	E.	fair		Wind E.; steady, but light all these twenty-four hours; swell still from the S.S.E.; latitude observed 29° 50′, longitude p. chronometer 74° 37′ 20″ W.; barometer as yesterday.
				Wednesday, August 16, 1837.
P.M.	E.N.E.	fair		Wind E.N.E.; steady and moderate, with a heavy lowering sky; at 4 P.M. in top-gallant sails and guff-topsail; at midnight do. weather; A.M. breeze freshening; at noon strong breeze with a very stormy appearance, the swell evidently increasing; latitude observed 31° 37′, longitude p. chronometer 74° 54′ 30″; barometer at fair.
A.M.				
				Thursday, August 17, 1837.
P. M.	N.E. by E.	change		Wind N.E. by E.; steady; the sky loaded to the eastward with heavy sluggish clouds, and apparently no distance over head; at 3 P.M. down royal yards; at 6 breeze freshening; in first reef of the topsails; at 7, in spanker, jib, and mainsail, set the trysails, and in second reef of the topsails; at midnight strong gale with high cross sea; up foresail; the mercury much agitated and inclined to fall; at 6 A.M. set the foresail again; at noon very hazy round the horizon, with the appearance over head as yesterday; latitude 33° 3′ N., longitude p. chronometer 75° 9′; barometer fallen to change.
A.M.				
				Friday, August 18, 1837.
P.M.	E.N.E.	change		Wind E.N.E. with the same wild appearance, and every indication of a dangerous change of weather; at 3 P.M. wore ship to the southward; in foresail and main-staysail; at midnight do. weather; barometer still falling; wind E.; gale increasing; close-reefed the topsails and stowed the foresail; at daylight in fore and main-topsails, down top-gallant-yards, and housed the top gallant-masts; in jib-boom, and stowed jib and fore-top-staysail in the net; came too under the storm mizen and main-trysail; at noon heavy gale of wind E.S.E.; sea running very high, the ship labouring much; the sky as if closing around us, and having a most dismal appearance; no observation; barometer from stormy to change, but impossible to set it in consequence of the ship's labouring; in dead lights.
	E.	falling		
	E.S.E.			
		stormy		
				Saturday, August 19, 1837.
P.M.	S.S.E.	change		Heavy gale with violent squalls and rain; at 6 P.M. blowing a hurricane, the sea continually breaking over the ship; one pump constantly kept going; at 11.30 shipped a tremendous sea, which carried away the whole of the bulwarks and some of the stanchions on both sides of the main deck, some spare spars, and lee-beam; at midnight the scene most appalling, the wind lashing; the foam and rain, so as to render it impossible to look to windward; the ship literally under water forward; about this time the starboard quarter-boat was blown from her lashings, and we saw no more of her; at 3 A.M. gale harder, if possible; blew the main trysail completely out of the bolt-rope, at the same time a succession of seas breaking over the ship, swept every thing off the decks but guns and long-boat; turned the hands up and rigged both pumps; at noon not the least appearance of a change; wind S.S.E.; dismally dark, and no observation; barometer as yesterday; wore ship.
A.M.				
				Sunday, August 20, 1837.
P.M.	S.S.E.	change		No alteration until 10 P.M. when the wind backed to the eastward, blowing as hard as ever; at midnight do. weather, the same terrific appearance; A.M. the wind gradually backing to the northward with no abatement; at noon wind N.N.W. but not the least abatement; no observation; barometer as yesterday.
A.M.	N.N.W.			
				Monday, August 21, 1837.
P.M.	N.W.	fair		At 1 P.M. wind at N.W.; the sea abeam and breaking over us as if determined to destroy all before it; got the storm mizen in and stowed; let her drift under bare poles; at 6 more violent, if possible; had the bulwarks on the poop washed away, and the larboard quarter-boat stove; at 8 set the mizen again; the breeze inclined to moderate, and the mercury to rise; at midnight still dark and gloomy; mercury getting up fast; at daylight moderated a little, and inclined to clear up; bore up and set the close-reefed top-sails and foresail; at 9 A.M. got sights for the chronometer; barometer rising rapidly; at 10 A.M. made more sail, with a fine steady breeze from the westward; ship making one foot of water per hour; at noon observed in 34° 38′ N., longitude per chronometer 74° 20′ 30″ W., having made since last observation, against wind and sea, ninety-five miles of northing, and forty-nine of longitude; barometer at fair.
A.M	W.			

Hurricane, middle of August, 1837.

"From this date to the 3rd of September we had variable winds and fine weather. On that day we spoke a brig from Matanzas to Bremen. She left Cuba on the 18th of August, with a fine westerly breeze, which brought her through the Gulf of Florida and alongside of us, over the same ground where so much damage had been so recently done.

"In 1824, when I commanded the ship New York packet, we encountered in September, homeward bound, to the northward of Bermuda, a heavy gale from south-east, which continued for two days, when it suddenly became calm. A small clear spot appeared in the opposite quarter, north-west; and in a very short span the ship was on her beam ends, with her lower yards in the water, from the action of the wind upon her spars and rigging alone. I was obliged to cut away some of her masts, or she must have foundered.

"In August 1832, between the Havannah and Matanzas, in the Sophia, I experienced a similar breeze to this last one, in company with several other Jamaica ships. I had paid close attention to the barometer, and other signs of a change of weather; and having prepared accordingly, suffered little or nothing in spars or rigging, when some of those in company were dismasted. On that occasion, ships not thirty miles off were not aware of it. It began at south-east, and going round the compass, westward, ended where it began in six hours.

"Lieut. Colonel Reid, R. E. (Signed) "JAMES BARCLAY."

Narrative of Mr. Macqueen, Master of the London and Jamaica Ship, Rawlins.

"Latitude — Commencement, N. 30° 30′
" Termination, 30° 40′
"Longitude—Commencement, W. 77° 40′
" Termination, 77° 18′
"Dates—17th, 18th, 19th August.

"Wind commenced at north-east by east, blowing strong from that quarter, about twelve hours, then suddenly veered to north, continuing with unabated vigour until midnight of
Calm. 18th; in an instant a perfect calm ensued for one hour; then quick as thought the hurricane sprung up, with tremendous force from south-west, not again shifting from that point. No swell whatever preceded the convulsion. The barometer gave every notice of the coming gale for many previous hours. Two days antecedent the weather beautifully serene, but oppressively hot, with light shifting airs; barometer during that time standing at 'set-fair,' during the gale as low as almost to be invisible, in the tube, above the frame-work of the instrument. The force subsided at midnight, August 19th; the sea tremendous, and rising in every direction; from the force of wind no tops to the waves, being dispersed in one sheet of white foam; the decks tenanted by many sea birds, in an exhausted state, seeking shelter in the vessel; impossible to discern, even during the day, anything at fifty yards distance; the wind representing numberless voices, elevated to the shrillest tone of screaming; but few flashes of lightning, and those in the south-west. A very heavy sea continued for some days after.

"GILBERT MACQUEEN, Commander of ship Rawlins."

In the log of the Rawlins there is this expression:

"20th August, 6 A.M.—The wind and sea much abated. A dismal appearance to the north-west."

Narrative of Mr. Turner, Master of the Ship West Indian, from Jamaica to London.

Hurricane, middle of August, 1837. Ship West Indian, (Turner.)

"August 14th.—Lat. observed 28° 28′ north, long. by chronometer 79 45′ west, current
Bar. 30in 1‴ N. ½ W. 90 miles since the previous noon; water smooth, and fine weather.
Bar. 30in 1‴ 15th.—Lat. observed 31° 9′ north, longitude by chronometer 79° 59′ west,
P.M. current north ‖ west, 90 miles since the previous noon; wind light from
E.N.E. east-north-east; smooth water. At 5 P.M. this day the weather put on an unsettled appearance, and a strong swell began to set in from the east-north-east, which continued to increase, as did also the wind from the north-east; the next morning the sky more settled.

Bar. 30in 0‴ 16th.—Lat. observed 31° 45′ north, long. by chronometer 77° 59′ west; no
P.M. current perceptible this twenty-four hours, although when the ship was tacked at 5 P.M. last evening, and quite on the inner edge of the Gulf-stream, the water at the surface was like a boiling cauldron; the heat of the water 8 and 10 degrees warmer than the air, which became equal
E.N.E. about midnight. Fresh winds, variable from east-north-east to north-east, gradually increasing.

Bar. 30in 0‴ 17th.—No observation. Lat. by account 31° 32′ north, long. by account 77° 13′
P.M. west; blowing fresh from yesterday, with a heavy swell from the east-
E.N.E. south-east (wind being east-north-east;) ship under reefed courses and double-reefed topsails. At daylight this morning the sky put on a very threatening aspect; ship's head to the east-south-east, with a tremendous sea from east-south-east; wind and sea continued to increase all day, with rain; barometer not falling until 5 P.M. when it went down suddenly 6‴; ship then under reefed forecourse and close-reefed main-topsail; top-gallant yards and mast on deck, jib-boom and mizen-topmast housed; at midnight took in forecourse. The hurricane
A.M. had now commenced, 3 A.M. of the 18th; in main-topsail; hurricane at its meridian; wind now about east-north-east.

Bar. 29in 1‴ 18th.—Ship now lying-to; main-topsail sheet partially hauled aft. Lat. by
P.M. account 31° 8′ north, long. by account 77° 56′ west; the wind drawing more easterly; constant heavy rain; sea running very high. At 6 P.M. the wind was east-south-east; struck by a sea; nearly swept the decks; carried away quarter-boats; quarter-gallery did considerable damage. The wind still inclining to the southward; just after midnight of the 18th it fell nearly calm; set main-topsail, and let a reef out to steady Calm.
A.M. ship. At 2 A.M. came out in an instant, with all its former violence, from the south-west; could not attempt to wear the ship on account of damage sustained on larboard quarter.

Bar. 28in 8‴ 19th.—Lat. by account 31° 21′ north, 78° 6′ west. Hurricane still continuing,
Midnight. with all its former violence; at midnight of the 19th it moderated a little,
A.M. wind veering to the westward all the time; at 4 A.M. the wind about west;

Hurricane, middle of August, 1837.

Bar. rising. got the ship before the wind under close-reefed topsails, and scudded before the gale; a tremendous cross sea.

Bar. 29in 3‴ 20th.—At noon, lat. by account 31° 42′ north, long. by account 77° 14′ west; continued to run before the gale all these twenty-four hours, the wind getting round to north-west; heavy cross sea.

Bar. 29in 5‴ 21st.—At noon, lat. by observation 33° 32′ north, long. by chronometer 72° 13′ west; now find the ship has been in the Gulf-stream great part of the time since the last observations were obtained. In four days ship has been set north 52° east, 130 miles; for some days after this had very unsettled weather, with a great deal of sea.

(Signed) "H. TURNER."

Brig Mary.

"Extract from the Log of the Brig Mary, J. R. Crosbie, Master, from Jamaica to Liverpool. Sailed from Kingston, July 29, 1837; Port Royal, July 30, 1837. Nothing particular occurred until the 3rd August, commencing with incessant rain, thunder, and lightning; a heavy cross sea.—*Civil Time.*

Hour.	Wind.	Bar.	Ther.	Remarks.
				August 4, 1837.
	Variable	29·1	83	Winds variable; current from the S.S.E. 1 mile per hour; latitude observed 20° 47′, longitude p. chronometer 83° 54′; barometer 29·1; thermometer, shade 83°.
				August 5, 1837.
	Variable	29·00	84	Winds variable; no current; latitude observed 20° 59′, longitude p. chronometer 84° 20′; barometer 29·00; thermometer, shade 84°.
				August 6, 1837.
	Variable	29·00	84	Winds variable; current S.E. by S. 1 mile per hour; latitude observed 21° 28′, longitude p. chronometer 84° 46′; barometer 29·00; thermometer, shade 84°.
				August 7, 1837.
	Variable	29·00	83	Winds variable; no current; light winds; latitude observed 23° 4′, longitude p. chronometer 84° 46′; barometer 29·00; thermometer, shade 83°
				August 8, 1837.
	Variable	29·20	81	Winds variable; squally and cloudy throughout; latitude observed 23° 19′, longitude p. chronometer 84° 28′; barometer 29·20; thermometer, shade 81°.
				August 9, 1837.
	Variable	29·60	82	Winds variable; squally and cloudy throughout; current S. 1 mile per hour; latitude observed 23° 12′, longitude p. chronometer 83° 45′; barometer 29·60; thermometer, shade 82°.
				August 10, 1837.
	Variable	29·60	82	Winds variable; no current; baffling; thunder and lightning; latitude observed 23° 12′, longitude p. chronometer 83°; barometer 29·60; thermometer, shade 82°.
				August 11, 1837.
	Variable	29·50	82	Winds variable; light winds and cross sea; current to the N.E. 2 miles per hour; latitude observed 24° 10′, longitude p. chronometer 81° 31′; barometer 29·50; thermometer, shade 82°.
				August 12, 1837.
	Variable	29·60	82	Winds variable; light winds and cross sea; current N.E. by E. 2 miles per hour; latitude observed 24° 48′, longitude p. chronometer 80° 14′; barometer 29·60; thermometer, shade 82°, water 82°.
				August 13, 1837.
	Variable	29·12	82	Winds variable; current N. by E. ½ E. 3 miles per hour; latitude observed 26° 51′, longitude p. chronometer 79° 37′; barometer 29·12; thermometer, shade 82°, water 82°.

Account of the Brig Mary—*continued.*

Hurricane, middle of August, 1837.

Hour.	Wind.	Bar.	Ther.	Remarks.
				August 14, 1837.
	E. by N.	29·12	83	Wind E. by N.; light airs; current N. 4 miles per hour; latitude observed 29° 22′, longitude p. chronometer 79° 33′; barometer 29·12; thermometer, shade 83°, water 83°.
				August 15, 1837.
	Variable	29·70	82	Winds variable; current N. 2 miles per hour; latitude observed 31° 3′, longitude p. chronometer 79°; barometer 29·70; thermometer, shade 82°, water 82°.
				August 16, 1837.
	E.S.E.	29·10	82	Wind E.S.E.; current N.N.E. 2 miles per hour; latitude observed 32° 21′, longitude p. chronometer 77° 50′; barometer 29·10; thermometer, shade 82°, water 82°.
				August 17, 1837.
	E. by N. N.E. by E.	29·00	82	Wind E. by N., N.E. by E.; strong gales and heavy squalls, with a head sea from N.E.; barometer 29·00; thermometer, shade 82°, water 82°.
				August 18, 1837.
	E.S.E.	falling 28·70	80	Wind E.S.E.; increasing gales; struck top-gallant-yards and masts; secured all on deck; every appearance of bad weather; barometer falling fast; labouring and straining; lying-to under balance-reefed trysail; barometer 28·70; thermometer, shade 80°, water 82°.
				August 19, 1837.
	S.E.	28·60	76	Wind S.E.; gale increasing to a perfect hurricane; under bare poles; barometer 28·60; thermometer, shade 76°, water 80°.
				August 20, 1837.
	E.S.E.	rising falling 28·50	74	Wind E.S.E.; sea making a complete break over all; barometer rising and falling very fast; unsettled for the last twenty-four hours; seldom get below to look at it; barometer 28·50; thermometer, shade 74°, water 78°.
				August 21, 1837.
A.M.	S.E. to N.W.	rising	70	Wind from S.E. to N.W.; barometer 28° 10′; a terrific appearance; thermometer, air 70°, water 76°; under bare poles; nothing can withstand the wind at present; secured all on deck as well as possible; sent all but three men off deck; at 5 A.M. tremendous sea struck the vessel on the larboard bow, which took away all bulwarks, stanchions, boats, spars, water-casks, caboose, and every moveable off deck, stream and kedge anchor; vessel laying on her broadside, unfortunately lurched; one seaman and mate overboard; picked him up, with imminent risk of my own life, but had his leg broken; another man his arm, and had more disabled; one man found himself under the foretop when he recovered himself; the hurricane continuing to rage more and more; every exertion made to save as much as possible; at noon gale abating; barometer rising gradually; I could not leave the deck to note it, but it certainly must have been lower, noon 28·40; thermometer, shade 70°; water 76°;
P.M.		28·40	70	P.M. latitude 36° 12′ N., longitude p. chronometer 72° 11′ W.; a turbulent cross sea; vessel very labboursome; midnight set the reefed square mainsail, all other sails being blown away.
				August 22, 1837.
	S.W.	28·80	Ther. broken	Wind S.W.; made all sail that circumstances would permit; heavy rain, thunder, and lightning; latitude 36° 22′, longitude 70° 6′ W.; barometer 28·80; thermometer broken.
				August 23, 1837.
	S.W. to N.W.	28·90		Wind S.W. to N.W.; latitude 36° 22′, longitude 68° 17′; barometer 28·90.
				August 24, 1837.
	N. by E.	29·00		Wind N. by E.; latitude 36° 13′, longitude 66° 45′; barometer 29·00; thermometer moveable and gloomy.
				August 25, 1837.
	N.W.	29·00		Wind N.W.; latitude 36° 35′, longitude 65° 38′; barometer 29·00.

"The remaining part of the passage strong breezes from the westward; barometer rising gradually. The use of this valuable instrument every master mariner ought to pay strict attention to. I would strongly recommend no one to go to sea without it, having had one for six years; I always placed the greatest confidence in it: as also the thermometer, when strictly attended to. The barometer I have invariably found to act more to the north-

Hurricane, middle of August, 1837.

ward of 30°, than to the southward of that lat.; unless when some great alteration in the weather is about to occur; and thermometers always noted at noon each day. I had no sympiesometer on board.

(Signed) "J. R. CROSBIE, Master of the brig Mary."

Ship Penelope.

Extract from the Log of the Barque Penelope, J. H. GRIMES, Master, from Jamaica to London.—In *Nautical Time*.

Hour.	Wind.	Bar.	Ther.	Remarks.
				August 19—*Nautical Time.*
P.M.	E.S.E.			Strong gales, and cloudy. At 4 P.M. (18th mean time) larboard pump choked; ship labouring much, and making a great deal of water; midnight strong gales; kept the ship off the wind occasionally, to pump the ship out with weather-pump; at 3 A.M. (19th) wore ship to the southward; took in fore-course, and close-reefed the topsails; wind E.S.E.; at 6 A.M. wore ship to northward; at 10 A.M. (19th) hard gales; in fore-topsail and fore-topmast staysail, and hove-to under close-reefed main-topsail; latitude, by account at noon, 34° 56′ N., longitude 75° 2′ W.
				August 20—(19 P.M. Mean Time.)
P.M.	N.E.			Hard gales, and a heavy sea; at 4 P.M. (19th) gale increasing; starboard pump constantly going; ship labouring much, and making much water; at 8 P.M (20th) tremendous gales; ship laying with gunwales in the water, on the larboard tack; at 11 P.M. hoisted the fore-topmast staysail, and wore ship to the N.E.; a very heavy sea running, when the ship came to the wind on the other tack; fore-topmast staysail blew away, and the main-topsail was split. Midnight; a heavy sea broke on board and washed the boats to the lee-side of the deck, and carried away bulwarks on both sides, fore and aft; at 2 A.M. (20th, *civil time*) set main-trysail, to keep ship to; in five minutes it blew away in tatters; wind from E. to S.E., one pump constantly going; at 4 A.M. sounded the well, and found nearly three-foot water in the weather pump; called all hands to the pump, and found the sand had washed from the bottom of the larboard pump; set both pumps on; at daylight found the plankshear on the larboard side had started off half an inch for three feet in length; at 8 A.M. wind moderated; secured the long-boat and spare anchors; pumps still going; sugar washing out very fast; at 10 A.M. (20th) wind more moderate; set close-reefed fore-topsail; wind E.S.E. to E. Noon, dark cloudy weather; wore ship to southward; noon, latitude account 35° 20′, longitude 75° 20′ W.
A.M.	E.S.E.			
	to E.			
				August 21—(20 Mean Time.)
P.M.	N.E.			Strong gales, and cloudy; at 2 P.M. got the ship pumped out to twelve inches, when the larboard pump choked again; at 4 P.M. wind E.S.E.; wore ship to N.E., not laying to well; at 9 A.M. gale increasing; and the wind having veered to the N.N.W., a very heavy sea running, and the ship getting topheavy from the quantity of sugar washed out; came to a resolution of running before it till the gale abated; at midnight it blew a perfect hurricane from N.N.W.; at 4 A.M. (21st August, mean time) a heavy sea broke on board, and stove the boats on deck, so we were obliged to throw the pieces overboard, likewise every thing off the deck, water-casks, stream anchor, &c.; at 8 A.M. saw a French brig scudding under ■ foresail, apparently with no accident; at 10 A.M. more moderate, ship making much water; and one pump being choked, deemed it prudent to get into some port in America. Noon, latitude 34° 30′ N., longitude by chronometer 72° 20′ W.
A.M.	N.N.W.			
				August 22—(21 Mean Time.)
P.M.	S.W.	broke		At 6 P.M. wind hauled to the S.W.; made up my mind to gain a port to the northward of Cape Hatteras; found by observation that the *current had increased in velocity during the gale*, and drove the ship considerably to the northward and eastward, eastward of where I expected her to be. Barometer being broke, it was useless. The general appearance of the weather was dark and cloudy, but no lightning. The latitudes and longitudes for the first two days will be very incorrect, as there was little time to attend to any thing else but the pumps, but on the 21st they are by observation. On the night of the 20th we had run about eighty miles due S., which would have made the latitude by account, on the 21st, about 33° 20′ N., whereas by observation it was 34° 50′ N., and longitude 72° 20′ W.; the latter part of the hurricane from N.N.W.; during the night it was very dark, and heavy black clouds, though, if I recollect right, the moon was in her last quarter.
	N.N.W.			(Signed) J. H. GRIMES, Commander of the Penelope.

Extract from the Log of the Barque West Indian, SIMPSON, Master, from Jamaica to London. In *Civil Time*.

Hurricane, middle of August, 1837.

Ship West Indian, (Simpson.)

Hour.	Wind.	Bar.	Ther.	Remarks.
				August 20.
P.M.	N.	falls		Increasing breezes, and dark gloomy weather; the wind not steady, shifting about from point to point, and dying into a calm, every now and then with heavy drops of rain; at times the marine barometer and sympiesometer fall very little; the weather-glass brushes up for a strong gale at noon; latitude 37° N., longitude 64° W.; in all studding-sails, royals, flying jib-gaff-topsail, unrove all the studding-sail gear, and sent the booms of the yards down; during these twenty-four hours the wind has been variable from S.W. to E.; at 5 P.M. passed the brig Constitution, of Rochester, water-logged and dismasted.
	S.W. to E.			
				August 21.
A.M.	N.E.	down		A.M.—Increasing gales, and squally; in top-gallant sails; a heavy sea from N.E.; the wind is variable from S. to S.E., and a heavy sea from that quarter likewise; at ■ A.M. in double reef of the topsails; people employed unbending all small sails, and sending the flying jib-boom in and gear; carpenter unshipping the bulwarks and stowed them below, and battening down and securing all the hatchways; at 10 strong gales; doubly stowed and passed the mainsail, jib, and mizen, and unrove the gear of the mainsail; at noon hard gales, and hazy, with ■ cross confused sea; barometer and sympiesometer down below rain; latitude by account 38° 23′ N., longitude 62° 40′ W.; at 4 close-reefed the topsail, and reefed the foresail; at 6 P.M. hard gales; stowed the foresail and fore-topsail, and passed them to the yards; unrove the fore-tacks and sheets, and hove the ship to; head to the eastward, wind S.; at 10 P.M. blowing quite ■ hurricane; we are now involved in ■ white smoke or fog, and the water as white ■ a sheet; the main-topsail is on the cap, and the sheets eased off a little to ease the sail; at midnight nearly calm.
		below ■		
P.M.	S.			Calm.
				August 22.
A.M.	W.			At 1 A.M. the wind came away from about W., and if possible it blew harder than ever; at 6 A.M. it is blowing a hurricane; the ship is laying with half the lee main-deck in the water; three men lashed to the lee bilge-pump, and trying the main pump every ten minutes; the boat on the lee side has broke both davits; secured the boat with tackles from the mizenmast; it is blowing so hard now that the sea is smooth at times, and the water is coming over the weather-rail like a waterspout; 8 A.M. the ship is now laying with her lee-rail under water, the ship making more water than usual; pumps constantly going; at noon, the gale is now at its height; it is dreadful; you cannot make the people hear what is said, and you can hardly see for the lashing of the rain and sleet; latitude by account 39° 9′ N., longitude 61° 34′ W.; at 2 P.M. more moderate; at 4 bore away; set the foresail and fore-topsail. We sailed from Jamaica, August the 1st, and arrived in the Downs on the 11th of September; we had nothing but fine weather before and after the gale. I have made forty-eight passages across the Atlantic Ocean; I have always met with more hurricanes, thunder, squalls and tempestuous weather within the influence of the Gulf-stream, than I have found either to the northward or southward, and I cannot account for it.
P.M.				(Signed) HENRY SIMPSON.

Ship Ida.

Extract from the Log of the Ship Ida, TILLEY, Commander.—In *Civil Time*.

Hour.	Wind.	Bar.	Ther.	Remarks.
				Tuesday, August 15, 1837.
A.M.	E.N.E.	30·10	85	A.M.—Light breezes and cloudy weather; at 5 light airs and variable, with rain, thunder, and lightning, wind veering round the compass; the sky at this time had a very curious appearance, streaky and resembling a water-spout, and sometimes that of a rainbow; this weather continued till 10 o'clock, when it became fine; at noon light breezes and fine, made sail; latitude observed 27° 31′ N., longitude by chronometer 79° 36′ W.; thermometer 85°; marine barometer 30·1-10; at 6 tacked ship to the eastward; at midnight light breezes and cloudy weather; tacked to the northward; wind E.N.E.

Hurricane, middle of August, 1837.

Ship Ida.

Report of the Ida—*continued.*

Hour.	Wind.	Bar.	Ther.	Remarks.
				Wednesday, August 16, 1837.
A.M.	N.E.E.			A.M.—Light breezes and squally weather; at daylight set top-gallant sails; at 9 in top-gallant sails; at noon fresh breezes and squally weather; latitude observed 29° 54′ N., longitude 79° 39′ W.; thermometer 80°; marine barometer 29·8-10; P.M. strong breezes and squally; in second and third reef of the topsails; sent down the royal yards; at 3 wore ship to the eastward; wind N.N.E.; at midnight strong breezes and cloudy, with a swell from the eastward; marine barometer 29·2-10.
P.M.		29·80	80	
		29. 20		
				Thursday, August 17, 1837.
A.M.	N.E. to E.S.E.			A.M.—Fresh gales and squally weather; at 4 handed the fore-topsail, and foresail; at intervals the wind came in gusts, then suddenly dying away, and continued so for four hours; sent down top-gallant-yards and masts on deck; at 8 hove to under close-reefed main-topsail and main-trysail; at 9 split the main-trysail; at 10 the main-topsail blew from the bolt-rope; at noon blowing a hurricane; marine barometer 29°; no latitude, no longitude; wind N.E.; head to E.S.E.; laying to under bare poles; at 8 P.M. shipped a heavy sea which washed away the caboose and bulwarks on the lee side; at 10 shipped a heavy sea on the weather quarter, which stove in the companion, and washed away all the after bulwarks, the lee quarter-boat was completely blown to pieces by the wind; at midnight blowing a tremendous hurricane, with rain and a heavy mountainous sea; ship labouring heavily, and shipping great quantities of water fore and aft; four feet water in the hold; used every exertion to free the ship without success; marine barometer 28·5-10.
P.M.		29·00		
		28·50		
				Friday, August 18, 1837.
A.M.	N.E. to S.W.			A.M.—Blowing a tremendous hurricane, the wind veering from N.E. to S.W. within the last twelve hours, and every sail blown to atoms from the yards and from under the gaskets; all the pumps choked with ballast; the ship was laying over in a most awful state; at 5 P.M. succeeded in getting the ship before the wind, which we expect prevented her from foundering; at 8 found to our great joy the ship made much better weather scudding than laying too; at midnight found we had run out of the hurricane, but it still blew a very heavy gale; water in the hold increased to six feet; all the pumps choked; five men ill with fever, four disabled by accident, the remainder much fagged by long exertions, having nothing to eat but raw meat.
P.M.				
				Saturday, August 19, 1837.
A.M.	W.			A.M.—Strong gales with a high sea; at daylight all hands employed in lifting the pumps to clear the ballast, but no one could stay in the pump-well to effect it, in consequence of foul air; got one of the bilge-pumps to work, and one of the main-pumps lifted six feet out of its original place, it threw water badly; at noon strong breezes and cloudy weather; hauled our wind and made sail for some port in America; five men ill with fever, four off duty by falls, and the remainder much fagged by long exertion; wind W.
				Sunday, August 20, 1837.
A.M.				A.M.—Strong breezes and cloudy weather; people all employed at the pumps, but nearly worn out by fatigue and want of rest; at noon ditto weather, seven feet water in the hold, and it still increasing fast; employed at the pumps, which threw but very little water; latitude observed 31° 36′ N., longitude 76° 9′ W.; thermometer 65°; marine barometer 29·5-10; some of the people employed getting spars ready for a raft in case the ship should founder during the night: at midnight more moderate, eight feet water in the hold; the wind from the westward all these twenty-four hours.
	Westward	29·50	65	
				Monday, August 21, 1837.
A.M.	S.W.			A.M.—Fresh breezes and cloudy weather; at daylight to our great joy saw a ship to windward, with her mizen-mast and top-gallant-masts cut away; made a signal of distress to her, she bore up and came down on us; at 6 spoke her; she proved to be Citizen, of New York, from New Orleans, bound to Bremen, now to the nearest port she could reach, being in great distress as well as ourselves, making three feet and a half of water per hour; we consulted, and entered into an engagement to stay by each other; at 9 took off the hatches, and began to lighten the ship from the between decks, by throwing overboard coffee, rum, and ship stores, and every thing that impeded lightening the ship, as we were under great apprehension of the ship's capsizing, as we had two tier

Report of the Ida—*continued.*

Hour.	Wind.	Bar.	Ther.	Remarks.
				Monday, August 21—*continued.*
A.M.	S.W.			of sugar washed out of the lower hold; as the pumps proved of little service commenced baleing out the ship with buckets; but as she had ten feet water in the hold, thought our longer exertions would be of little avail: at 8 spoke the Citizen, and informed her commander that we should abandon our ship at daylight; at midnight strong breezes and squally, the ship having so much water in her we could scarcely get her to answer her helm; wind this day S.W.; latitude 32° 7′ N., longitude 7° 30′ W.
				Tuesday, August 22, 1837.
A.M.	S.W.			A.M.—Light breezes and fine weather; at 4 strong breezes and squally weather; made a signal of distress to the Citizen, and finding all our endeavours in vain to save the ship with our worn-out crew, got the boats ready and made preparations for abandoning her; at 6 the Citizen stood towards us; at 7 we hove-to near each other, out boat and sent part of crew on board; the boat returned three times, when we succeeded in getting all the crew safe on board the Citizen, although it blew very strong, and the ships were obliged to bear up to pick up the boat, as the wind blew so heavy, they could not pull to windward; latitude 33° 14′ N., longitude 75° 19′ W. when abandoned; and landed at Philadelphia on the 30th of August. (Signed) JAMES TILLY.

Extract from the Log of the Ship Westbrook, J. FREEMAN, Commander, from Jamaica to London.—In *Nautical Time.*

Ship Westbrook.

Hour.	Wind.	Bar.	Ther.	Remarks.
				August 15, 1837—(14 Mean Time.)
P.M.	Variable			5 P.M light air, approaching to calm; midnight, heavy swell from the S.E.; noon, latitude 31° N., longitude 78′ W.; wind variable.
				August 16, 1837—(15 Mean Time.)
P.M.	Variable			1 P.M. light baffling winds; 7 P.M. increasing wind, and looking squally; in small sails; midnight, wind E.S.E.; steady wind and clear; noon, latitude 32° 20′, longitude 76° 43′; wind variable.
	E.S.E			
	Variable			
				August 17, 1837—(16 Mean Time.)
P.M.	N.E.			1 P.M. wind N.E.; fresh wind and clear weather, with a S.E. swell running; 6 P.M. in top-gallant-sail and single-reefed topsails; strong wind, with a very heavy sea from the S.E.; 8 P.M. a very heavy appearance in the S., with a good deal of lightning; stowed the mainsail; 7 A.M. strong gales, and a very heavy sea; vessel shipping a good deal of water; 9 A.M. in second reef in topsails; noon, strong gales and very heavy squalls, with rain; latitude 32° 47′, longitude 76° 14′.
A.M.				
				August 18, 1837—(17 Mean Time.)
P.M.	E. by N.			1 P.M. wind E. by N.; strong gales and hard squalls, with a high cross sea running; midnight, strong gales and squally; 5 A.M. wind E.; noon, blowing strong, and no appearance of change; close-reefed the topsails and down royal yards; no observation.
A.M.	E.			
				August 19, 1837—(18 Mean Time.)
P.M.	S.E.			1 P.M. wind S.E.; strong gales, and a heavy sea running; 3 P.M. stowed the foresail; 8 P.M. stowed the fore-topsail, being split, and hove-to under close reefed main-topsail and trysail; midnight, came on to blow a complete hurricane; sea rising very high; vessel labouring heavy, and shipping quantities of water on all sides; noon (19th), no appearance of any change.
				August 20, 1837.
A.M.	S.E.			Wind at S.E. until 11 A.M. on the 20th, when it veered to N.N.W.; throughout these twenty-four hours a terrific hurricane; the sea awfully high; vessel labouring as before, and shipping quantities of water on all sides; a heavy sea struck the jib-boom, and carried away the spritsail-yard, jib, and flying jib-boom; the ship pitching so very heavily, we were obliged to cut away the wreck for safety; lost at the same time both jibs; sprung the fore-top-gallant-mast; split the main-trysail; heavy rain throughout; no observations.

Report of the Westbrook—*continued.*

Hour.	Wind.	Bar.	Ther.	Remarks.
				August 21, 1837.
A.M.	N.N.W.			Wind N.N.W.; not the least alteration in wind or weather; vessel labouring as before, and shipping quantities of water on all sides; rain and thunder; midnight, just the same; 4 A.M. more moderate; bore away, and set the fore-sail and fore-topsail; latitude 34° 58′, longitude 73° 32′.; wind W.N.W.
				August 24—(Mean Time.)
Noon P.M.	Variable			At 1 P.M. wind variable, and ▪ heavy southerly swell; at midnight ▪ heavy easterly swell.

The following Report of the Master of the Yolof, which was sworn to before the "Tribunal" of Havre de Grace, was transmitted by the British Consul:

Cópie du Journal de Mer du Capitaine HEBERT.

French brig Yolof.

"Nous soussignés, capitaine, officiers et matelôts composant l'equipage du brigantin Français Yolof, du Havre. Certifions et attestons que nous sommes partis de la Havane, le huit Août, 1837, en destination du Havre chargés de tabac et café, &c., que nous sommes sortis le canal de Bahama avec differents tems, le 12 dudit, vents variables et faible brise jusqu'au Mercredi 16, que nous nous trouvions par 32° 14′ latitude nord, et 78° 50′ de longitude ouest de Paris (76° 25′ west of Greenwich.)

"Alors les vents commencerent à souffler de la partie d'est-nord-est, pris 2 ris aux huniers, dégrée les Cataçois; le vent augmentant toujours mis à la Cape sous le grand hunier, le navire fatiguant beaucoup, l'eau difficile à obtenir à la pompe, par les grandes cousses qu'éprouvait le navire, continuation de même tems jusqu'au Jeudi 17, que la tempête la plus affreuse s'est déclarée, recevant de très mauvais coups de mer, le canot enlevé, le logement de l'equipage et la chambre remplies d'eau.

"De 8 heures à minuit ne pouvant plus tenir à la Cape, hissé le petit foc pour laisser arriver vent arrière. Le grand hunier fut enlévé en ce moment, tonnères et éclairs, pluies continelles, à une heure et demie. Le petit foc enlévé, deux hommes à la barre ne pouvant tenir le navire vent arrière, coupé les haubans et calhaubans du grand mât de perroquet, cassé aussitôt et tombé à la mer avec la vergue, ne pouvant encore arriver et le navire étant entièrement chaviré au troisième coup de mer que nous reçumes par le travers, defoncé une partie des pavois, et fait couper pour le salut commun du navire et de la cargaison. Le grément du grand mât de hune cassé, à 2 pieds du chouque; cinque minutes après coupé le grément de la vergue et du mât et laissé aller à la mer la grande voile enlévé par morceaux quoique bien serrée, aussitot le grand mât de hune cassé, le navire s'est un peu redressé faisant beaucoup d'eau, deux hommes continuellement à la pompe toutes les barriques à eau, cages à poules, charniers, saisines, office de cuisine et autres objéts qui étaient sur le pont enlevès; à 4 heures du matin le tems toujours le même, dans un grain le navire étant venu au vent malgré sa barre, le mât de misaine a cassé, au ras du cercle de drosses, coupé de suite le grément ainsi que celui du petit hunier, les mâts et les vergues donnant de fortes secouses à la coque du navire, et ne pouvant rien sauver à cause de la grosse mer, laissé tout aller à fin de ▬ pas défoncer le navire.

"Au Jour nous étions dans un état déplorable tout l'équipage exterminé de fatigue, 2 hommes blessés et ne pouvant plus donner la main au travail. Impossible de consolider la grande vergue, dont les balamines et les drisses et bras étaient rompues, ce qui a occasionné de grandes avaries dans le grément du grand mât et ▬ mât. La chaloupe brisée sur le pont par les grands coups de mer et le bout de la vergue de misaine, qui en tombant porte dessus.

"Le vendredi 18 de 8 heures du matin à midi grand vent et pluie, travaillé cependant jusqu'au soir à établir un hunier de misaine sur le trognon du mât et le grand foc à mi bâtou, à 8 heures au soir calme, mer toujours grosse, etabli les deux voiles que nous avions installés à fin de rélacher à Charleston, dans l'intérêt des assureurs et chargeurs, si toutes fois le tems nous le permettait; à peine établis, le vent ▪ eclaté en foudre au west-nord-west. Defoncé le hunier et le grand foc avant que de pouvoir les serrer, toutes les ralingues et la toile de foc partis, tems affreux toute la nuit, pompant beaucoup de café, le 19 la pompe de tribord engagée, ne pompant qu'à babord, même tems jusqu'au Dimanche 20, que le ciel se debrouilla un peu vers les dix heures du matin, travaillé à etablir notre dernier hunier en misaine et le petit foc. Ce jour, latitude 32° 0′ nord, envergué un autre brigantine, affranchi la pompe de tems en tems, le navire fatiguant moins. Le Lundi 21 le tems assez beau, consolidé la grande vergue et envergué une misaine neuve dessus, mer toujours houleuse, dans la nuit calme, parlé à un trois mâts sorti de Boston et allant à la Nouvelle Orléans. Petite brise de sud-ouest, fait gouverner pour nous approcher de la terre le plus possible, degagé la pompe de tribord et mis une plaque de cuivre au bout à fin qu'elle ▬ s'engagât plus de nouveau. Vent variable toute la nuit, au lever de la lune petite brise de nord-est, pris les amors à tribord et fait gouverner au ouest. Le Mercredi 23 étant par 76° 40′ longitude ouest (74° 15′ west of Greenwich,) et 33° 45′ latitude nord. Les courants nous ayant drossé nord; apperçu à 8 hueres du matin un 3 mâts ses mâts cassés au ras du pont son beaupré seul deployé. Fait gouverner au nord, à fin de sauver l'équipage s'il était encore abord, nous étant approchés à un mille de distance et ayant fait de dedans la hune de signeaux, personne n'ayant répondu, nous avons continué notre route pour Charleston."

From Mr. MONDEL, Commander of the ship Castries, from St. Lucia to Liverpool: Ship Castries.

"We left the island of St. Lucia at 6 P.M. on the 11th August, *nautical time* (10th August mean time,) with a light northerly wind, passing through between St. Lucia and Martinique; the wind continued light and variable for three succeeding days, but with much lightning.

"On the 15th P.M. (14th *civil time*,) wind south-south-west to souh-east; very squally, with much thunder, lightning, and rain, and by noon the trade-wind blew steadily at east.

"During the night of the 15th (I speak from memory) the brig Scipio, from Demerara to Dublin, experienced a hurricane, and on the following morning spoke a French ship that had been dismasted in it.

"I am sorry I cannot give the corresponding latitude and longitude of this vessel (the Scipio.) She arrived thirty-six hours after me in Dublin, and I had her log-book, but made no memorandum. We had no swell in this instance, but it was very dark dismal weather, so that even the most experienced saw something to be afraid of; however we escaped.

"The hurricane of the 25th of August was not preceded by any very particular symptoms of the weather. It blew steadily from the east-south-east for the preceding twenty-four hours; and at 4 P.M. on the 25th (24th mean time,) we had split an old jib, and bent another with the intention of setting it; a certain proof, up to that hour, that the weather did not look very bad. But as the gale increased the wind veered to the north, and the rain came down in torrents, and continued to do so until the following morning, when the gale abated.

Log of the Castries from St. Lucia, as far as latitude 39° 41′, longitude 50° 4′.—Kept in *Nautical Time*.

H.	K.	F.	Courses.	Winds.	L. W.	Remarks on board.
						August 12, 1837.
2	5		N.E.	W.S.W.		Light winds and pleasant weather; Point Ferre, Martinique, N. 1 W; all staysails set;
4	5					in all do.; wind from N.E. with rain.
6	4			West.		
8	3					At sunset much lightning.
10	..		Calm			Midnight.
12	2					Out all staysails on larboard side.
2	2		N.E. b. N.	S.W.		
4	2					
6	3					
8	3					
10	3			South.		
12	3					Light breezes and clear weather.

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff. Long.	Long. by Account.	Longitude by Obs.	Longitude by Chron.
..	..	..	..	..	15.10	..	60.10		
									August 13, 1837.
2	3		N.N.E. ½ E.		S.E.				Light breezes and clear weather.
4	3	4							
6	3								In all larboard staysails.
8	4		N. 1 W.		E.N.E.				
10	4								In all larboard staysails; lightning.
12	3								Midnight.
2	2	4	N. 1 W.						Slight showers of rain.
4	2		N.N.W.				¼		
6	2								
8	3								
10	3								Fair light trade winds.
12	4								
N. 9 W.	68	66	10	16.16	16.26	11	60.21	..	60.40

Log of the Castries—*continued.*

H.	K.	F.	Courses.	Winds.	L. W.	Remarks on board.
						August 14, 1837.—(*Civil Time.*)
2	3		N.W. 6 W.	N.N.E. to		Light unsteady breezes and cloudy; all sail set by the wind.
4	2	4		N. 1 W.		8, in royals and flying jib.
6	2	4	W. 6 N.			10, squally with rain.
8	4		N.E. 6 E.			Midnight, wind veered round to the N.E.; stood on starboard tack.
10	3	4				4, tacked eastward.
12	3		E. 6 N.			8, set foretop main-staysail and main-royal.
2	4		N.W. ½ W,			
4	2		W.N.W.	North		
6	4		N.E. 6 N.	N.W.		
8	4					
10	5					
12	6			S.W.		Set low and main-top-main-staysail.

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff. Long.	Long. by Account.	Longitude by Obs.	Longitude by Chron.
17 E.	53	52	15	17.18	..	16	60.5	..	60.17
									August 15, 1837.—(14 at noon, *Civil Time.*)
2	7		N.N.E. ½ E.		S.S.W.				Fresh breezes and squally, with a dirty threatening appearance. 4, in all staysails; broke the stud-boom. 10, in main-top-gallant-sails; much lightning. 11, set main-top-gallant-sail. Midnight, more settled; set fore-top-gallant-sail and jib.
4	7				to				Midnight.
6	7				S.S.E.				
8	7								Heavy squalls, with thunder, lightning, and rain.
10	7								
12	7				S.E.				Fair and cloudy; out main-royal.
2	8								
4	■								
6	7								
■	7				E.S.E.				
10	7								
12	7								
N. 22 E.	171	158	64	19.56	19.36	1.6	58.59	..	59.00
									August 16, 1837.—(15 at noon, *Civil Time.*)
2	7		N. 1 E.		East		½		Fresh breezes and cloudy; all sail set by the wind.
4	7								
6	6		North						Settled; out fore-top, main-staysail, and flying jib.
8	6		N. 1 W.		E.N.E.				Midnight.
10	6								
12	7								Cloudy weather.
2	6								
4	6		N.W. ½ N.						Showery.
6	4								
8	5								Employed varnishing poop, &c. &c.
10	4								
12	5								
N. 17 W.	131	25	37	21.41	..	40	59.39	..	59.54

Log of the Castries—*continued.*

H.	K.	F.	Courses.	Winds.	L.W.	Remarks on board.
						August 17, 1837.
2	5		N.N.W.	N.E. ½ E.	½	Moderate breezes and pleasant weather.
4	5					
6	5					
8	5		N. 1 W.	N.E. b. E.		
10	5		N.W.			
12	5					Midnight, cloudy.
2	4		N. 1 W. ½			
4	5					Squally, with rain.
6	5		N. 1 E.			
8	6					
10	6		N.N.E.	E.S.E.		Increasing breezes and cloudy.
12	7					

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff. Long.	Long. by Account.	Longitude by Chron.	Longitude by Obs.
N. 15 W.	119	115	31	23.36	23.27	34	60.13	60.30	..

										August 18, 1837.
2	6			N.N.E.		E. b. S.				Fine breezes and clear; all sail set by the wind.
4	6									
6	6									
8	6			North						Set lower-main-top and top-gallant-staysail.
10	6		4	N. b. E. ½ E.		E. b. S.				
12	7									Squally, with rain.
2	7			N.N.E.						Midnight.
4	7									Light showers.
6	7									
8	6			N. b. E.						
10	5									Fair and warm.
12	4									
N. 7 E.	135	134	17	25.41	..	19	59.54	59.54	..	
										August 19, 1837.
2	4			North		E. b. N.				Light winds and fine weather.
4	4									
6	3									
8	3			N.N.W.						
10	4									
12	4									Midnight, clear weather.
2	4			N.W. b. N.						
4	4			N.N.W.						
6	4			N.W.						Light winds and fine weather.
8	4									
10	4									
12	3									
N. 25 W.	96	87	40	27.8	26.54	44	60.38	60.40	..	

Log of the Castries—*continued.*

H.	K.	F.	Courses.	Winds.	L.W.	Remarks on board.
						August 20, 1837.
2	3		N.W. b. N.	N.E. b. N.		Light breezes and pleasant weather.
4	3					
6	3					
8	3					
10	4		N.N.W.			
12	4					Midnight.
2	4		N. b. W.			Increasing breezes and cloudy.
4	4					
6	4					
8	4					Out top, main, and top-gallant-staysail.
10	3		N.N.E.			
12	3					

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff. Long.	Long. by Account.	Longitude by Chron.	Longitude by Obs.
N. 20 W.	77	72	27	28.6	28.3	30	61.8	61.12	..

										August 21, 1837.
2	2			N. b. E.		East		¼		Light airs and very warm weather; thermometer at sunset 87½°.
4	2									
6	2			N.N.W.						
8	2			North						Light airs; midnight.
10	2									
12	3									Increasing; set low staysail.
2	3			N.E. b. N.						
4	4									
6	4									Light breezes.
8	4									
10	3		4			South				
12	3									
N. 14 E.	62	60	59	29.3	29.3	17	60.51	60.48	..	
										August 22, 1837.
2	3					S.S.W.				
4	3			N.E. ½ N.		S.W.				Light winds and fine weather; out larboard staysails.
6	3									
8	3									Midnight.
10	4									Pleasant breezes.
12	5									
2	6			Chron. fast 2h		42m 20s				
4	5									
6	4									Light winds and clear.
8	4									At 8h 38m long. per sun and moon .. 59. 49¾.
10	4					South				,, ,, per chronometer .. 59. 44¾.
12	4									
N. 33 E.	104	87	56	30.30	30.31	1.5	59.46	59.36	59.41	

Log of the Castries—*continued.*

Course.	K.	F.	Courses.	Winds.	L. W.	Remarks on board.
						August 23, 1837.
2	3		N.E. b. N.	S.S.E.		
4	3					
6	4	4				Moderate breezes and pleasant.
8	5					
10	5			S.E. b. N.		
12	6					Midnight, increasing breezes and clear.
2	6					
4	6					Cloudy.
6	6					
8	6					
10	6					A high westerly swell.
12	6					

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff Long.	Long. by Account.	Longitude by Chron.	Latitude by Obs.
N. 28 E.	126	110	59	32. 14	30. 21	1. 9	58. 37	58. 40	58. 45

								August 24, 1837.
2	6		N.N.E.	E.S.E.				Moderate breezes and hazy ; all staysails set.
4	6							In flying jib and lower staysails.
6	6		N.E. b. N.					In main-top-gallant main-staysails and fore-royal.
8	7							
10	7							Midnight.
12	7							Fresh breezes and cloudy.
2	8							
4	9							
6	8		N.E. 1 E. ½ N.				½	Ditto ditto.
8	8							
10	8		N.N.E.					Strong winds ; in flying jib and gaff-topsail.
12	8							

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff Long.	Long. by Account.	Longitude by Chron.	Latitude by Obs.
N. 18 E.	176	167	54	35. 1	34. 56	1. 4	57. 33	57. 45	..

								August 25, 1837.
2	7	4	N.N.E.	E. b. S.				Strong winds and cloudy. 3, in top-gallant
4	5							sails ; increasing gales ; double-reefed both top-
6	3		N. ½ E.	E. b. N.			½	sails. 4, furled both courses ; split the jib ;
8	1	4					2	bent another. 6, close-reefed both topsails ;
10	1	4	N.N.W.	N.E.				blowing a hard gale with heavy rain. 9, fore-
12	1	4	(Midnight.)	N.N.E.			5	topsail sheet broke and split the sail ; furled it.
2	1	4		North				11, blowing a hurricane ; blew the main-topsail
4	1	4	S.W.	W.N.W.				out of the ropes ; got a boat-sail bent to the gaff,
6	1	4		N.W.				and another in the main rigging ; the ship keeps-
8	1	4						to well ; shipping much water over the lee-rail ;
10	5		E.N.E.					pumps carefully attended to ; washed most of the
12	5							larboard bulwarks away ; as the wind veered
								N. to N.E. and to N.W. the vessel was con-
								tinually with the sea, on or abaft the beam, which
								caused her to labour tremendously, and I am
								afraid has thrown some of the puncheons of
								molasses out of their berths, as the water is very
								much discoloured, and we can hear some of the
								casks rolling about.

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff Long.	Long. by Account.	Longitude by Chron.	Latitude by Obs.
N. 10 W.	41	40	7	35. 37	..	9	57. 42	57. 54	..

Log of the Castries—*concluded.*

H.	K.	F.	Courses.	Winds.	L. W.	Remarks.
						August 26, 1837.
2	5	4	N.E. b. E.	W.N.W.		Strong winds with a high cross sea.
4	6	■				Set jib, mainsail, and main-top-gallant-sail.
6	6	4				Set fore-top-gallant-sail and gaff-topsail.
8	7	4	N.E. b. ½ E.	N.W.		Sea more regular ; out topmain-staysail.
10	8					
12	8					Strong breezes and cloudy.
2	8					
4	8					Rain and lightning.
6	8					
8	8					
10	8		E.N.E.			Fair and strong breezes ; carried away fore-top-gallant-mast, sent it down ; ■ topmain-staysail.
12	8					

Course.	Dist	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff. Long.	Long. by Account.	Longitude by Chron.	Longitude by Obs.
N. 53 E.	180	108	144	37. 25	37. 9	2. 58	54. 44	54. 56	..

									August 27, 1837.
2	8		E.N.E	N.W.		½			Strong breezes and cloudy ; carrying moderate
4	8								sail, the rigging being much stretched and very
■	8								loose.
8	8								
10	8								Clear weather.
12	7								
2	7								Squally with rain.
4	7								
6	7								Set main-top-gallant-sail and spanker.
8	7								
10	7								Set fore-top-gallant-sail.
12	7								

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff. Long.	Long. by Account.	Longitude by Chron.	Longitude by Obs.
N. 63 E.	176	80	156	38. 29	38. 25	3. 10	51. 34	52. 26	..

									August 28, 1837.
2	6	4	N.E. b. E. ½ E.	N.W.					Fresh breezes and squally ; out low and
4	5								main-top-staysails.
6	4								Pleasant breezes and cloudy.
8	4								
10	6								
12	6	4		West.					
2	5								
4	4								
6	4								
8	3	4							
10	4			S.W.					
12	5								

Course.	Dist.	Diff. Lat.	Depar-ture.	Lat. by Account.	Lat. by Obs.	Diff. Long.	Long. by Account.	Longitude by Chron.	Longitude by Obs.
N. 50 E.	115	74	88	39. 39	39. 41	113	49. 41	50. 4	..

Further remarks relative to the Castries, on the 24th and 25th August, 1837:

"The hurricane commenced with the wind at east by south, and veered to the north-east as it increased. At 11 P.M. the hurricane blew from the north-north-east, *and veered about two points per hour* until 4.30 A.M. when it partially abated.

"We had a sudden *lull* whilst reefing topsails (at 4 P.M. on the 24th, by *civil time*).

"Had a high westerly swell for two days previous; but as this is very frequently the case about the termination of the trade winds, *I know not whether to ascribe it to the coming of this hurricane or to some preceding gale.*

"I had neither barometer nor sympiesometer. Before the storm it was very dark and hazy, with much lightning in the evenings.

"1, King Street, Liverpool. (Signed) "J. MONDEL."

"The Victoria, Dunn, from Lunenburg to Dominica, was upset and dismasted in a hurricane, 24th August, in lat. 33°. long. 58°, and abandoned on the 12th September."

"The barque Clydesdale, from Barbadoes and Antigua, encountered a severe hurricane ten miles north of Barbadoes, on the 26th of July, 1837. On the 24th of August encountered a hurricane more severe than the former, in lat. 32° 30′, long. 59° 30′, in which the vessel was hove on her beam ends, and remained in that position for two hours. She righted when the whole of her top-gallant-masts and rigging had been cut away."—*From the Shipping Gazette.*

From the Protest of the Clydesdale:

"On 23rd August, 1837, lat. 30° 21′, about noon, it came on to blow fresh breezes from the east-south-east, accompanied with a heavy confused swell. At 4 P.M. sent down main royal yards, and at midnight atmosphere dark, and wind south-east; close reef at 5 A.M. on the 24th. Took in all sail; at noon blew a complete hurricane; ship lying over very low, sea washing over. At 4 P.M. top-gallant-masts and yards cut away to save the vessel. At midnight gale moderated; at 4 A.M. of the 25th kept away; at 8 moderate, but still a confused swell.

The Castries seems to have crossed the track of the great hurricane on the 14th of August.

The storm which this vessel encountered on the 25th August, and the Clydesdale and Victoria on the 24th, appears to have been another and a separate storm; and judging from the log of the Castries, also a rotatory one. These two storms, approaching each other, serve as a second example of *a cause of variable winds.*

In the shipping reports of 1837, are further statements of a storm on the 2nd and 3rd of September, which passed to the southward of Cape Hatteras; which storm may in some degree explain the reason why a Bremen brig, which left Matanzas on the 18th of August, came up with and was alongside of the Sophia on the 3rd of September (see page 178). This last storm, passing over

Florida, had come from the State of Alabama, where on the 30th and 31st of August it caused much damage. Like all the others described in this paper, it appears to have been both progressive, rotatory, and limited.

The following are the published reports relative to this storm:

"APOLACHICOLA, Sept. 1, 1837.—I write from the midst of ruins. A hurricane yesterday swept our town and half destroyed it. Nearly every house is unroofed; a number of the upper stories are blown down, and many houses levelled. The storm commenced on the afternoon of 30th August, but was not severe until 4 A.M. on the morning of the 31st, when it became very violent until 7 P.M. The wind was from the south-east to north."—*Extract of a Letter published in the American Newspapers.*

"The terrible tempest which visited Apolachicola, completely destroyed the town of St. Mark's. The light-house was almost the only building left standing, yet the town of St. Joseph suffered very little in the gale."—*From the American Newspaper.*

"There has been a severe storm at St. Mark's, which commenced about sunrise on the morning of 31st August, 1837, the wind being from north-east. At 8 A.M. the wind was north, and it had increased in violence: only one wharf has been left standing. At the light-house the sea rose eight feet higher than usual. At Pensacola there was no wind. The schooner Lady Washington was becalmed at the same time at Key West. The wind was off shore at the time of the storm, which makes it difficult to account for the high tide; but it is supposed, *whilst the north-east wind was blowing on shore, a south-easter prevailed at sea. This is frequently the case, and invariably produces a high tide.*"—*New York General Advertiser.*

"On the 24th August, 1837, the wind was at north-west, with constant rain; and early on the 25th of August it rose, and came from the south-west quarter, so as to cause alarm. Between 10 and 11 A.M. the sea was agitated, and fears were entertained for the shipping. The wind became south. The Carron and Flamer steamers put to sea."—*Barbadian.*

"TREMENDOUS AND AWFUL GALE AT APOLACHICOLA.—Two hundred thousand dollars' worth of property destroyed—Buildings blown down, and twenty of their roofs blown off—Tide rose from ten to fifteen feet. On Wednesday, about 7 o'clock in the evening, a squall came up from the south-east, which continued increasing with considerable violence for about two hours; the wind then shifted to the **westward*, and about 11 o'clock it blew a pretty heavy gale; it gradually increased in violence until morning, when the tide had risen about six feet, covering our wharves some two or three feet. Every moment now seemed to add terror to the desolating scene: the rain descended in torrents, while the wind was blowing a perfect hurricane; every citizen was called upon to save the property likely to float away on the wharves, or the steam-boats or smaller crafts that were now in a sinking condition at the wharves; but all human exertion seemed to fail—the wind increased, and with it the rain, until it appeared as though heaven and earth would come together. About 12 o'clock, noon, the wind veered round to the northward and eastward, and with it an increase, if possible, of

* Probably a mistake.

the gale. The gale continued until about 12 o'clock at night, when it shifted to the north-west, and this morning we are again blessed with a clear sky."—*Jamaica Dispatch.*

"Another storm commenced about the middle of last night, and at 10 A M. this morning was blowing with some violence from the north-west. It continued with somewhat increasing violence until noon, when the wind veered to about west. It is now 2 o'clock, and it is still blowing a severe gale."—*From a Savannah Newspaper, Georgian, 31st August*, 1837.

"The ship Florence experienced a severe hurricane on the 2nd September, 1837, fifty miles east-south-east of Cape Hatteras. It commenced blowing at east-north-east, and veered round the compass."—*New York General Advertiser.*

"The Danish brig Maria, on the 2nd September, in lat. 36° 6′, long. 73° 40′, scudding in a heavy gale from the south."

"The brig Stranger, on the 2nd September, from Porto Plato in St. Domingo, to Philadelphia, experienced a severe gale from south, changing suddenly to north."

"On the 3rd September there was a severe gale off Cape Hatteras for ten hours."

"A British ship, water-logged, foremast gone, main and mizenmast standing, and had painted ports, was passed on the 29th ult., in lat. 30°, long. 79′. The wreck of a ship, abandoned and apparently recently dismasted, the sea breaking over her, and several articles floating alongside, was passed during a heavy gale on the 2nd September, 1837, in lat. 33°, long. 74°. This gale being to the northward of the Bremen brig, which came up with the Sophia (if she were within its influence), she would receive the wind from the west, and be carried on by it."

In some of the histories of the West Indies, it has been stated that hurricanes do not originate to the eastward of the Antilles; and such opinions have led to speculations on the subject, which are without foundation, as the following reports, as well as others already given, will show.

Reports relative to the gale which passed over Barbadoes on the 9th of July, 1837:

"The gale on the 9th July did some injury to the mills and houses in Barbadoes."—*From the West Indian, July* 10.

"The barque Trinidad, from the Clyde, experienced a severe gale of wind, approaching to a hurricane, on Sunday last, the 9th July, to the eastward of Barbadoes."—*From the Port of Spain Gazette, July* 10, 1837.

Extract from a letter in Lloyd's Books, dated Barbadoes:

"The whole of the 9th July the wind blew strong from north-east, with occasional heavy gusts, until 7 P.M., when it came in a severe gale. At 10 P.M. the wind moderated for a short time, when it began again, with increased violence, from south-east and south-south-east, until daylight next morning, when the gale abated. The schooners Myrtle and St. Andrews were driven on shore on the Pelican reef, to the leeward of Carlisle bay."

"ST. VINCENT, July 10. The weather has been boisterous during the night, and the wind was at west."—*From Lloyd's Books.*

"ST. LUCIA, July 19.—The island received a severe gale from the north and from the south, on the evening of Sunday, 19th July, and the morning of Monday, 10th July, 1837, during which the schooner Mary Ellice (M'Lean), then lying in the bay of Vieux Fort, was driven on the rocks, and the drogher Eliza driven on shore."—*From Lloyd's Books.*

(Signed) "WM. MASTERS."

Extract from a letter from Liverpool:

"On the 9th July the Castries (Mondel), from Liverpool to St. Lucia, in lat. 15° 4′, long. 54° 58′, having the wind then at east-south-east, the master being confident in his reckoning, his mate suddenly reported, 'Land on the lee-bow;' the man at the helm pointing it out at the same time: it had all the appearance of the broken outline of the West India islands, and looked as if within a mile and a half from them. Never doubting but that it was land, the captain trimmed his sails, that he might alter his course: when he had finished, he again looked for the land, when nothing like it was visible. On reaching St. Lucia, and hearing that there had been a hurricane there on the 10th, he concluded that what he had seen was this storm. The Castries had no barometer on board.

"Moon, 9th July, *nautical time* (8th mean time), wind east-north-east. At $3^h\ 52^m\ 2^s$, long. per sun and moon 51° 33′ west; $4^h\ 8^m\ 9^s$, long. per chronometer, 51° 59′ west; cloudy weather; at midnight strong breezes, and much lightning; 2 A.M. heavy squalls and rain. At noon, lat. by account 15° 3′, by observation 15° 4′; long. by chronometer 54° 58′, by observation 54° 18′; north point of St. Lucia, south 81° 12′ west; 353 miles.

"At $8^h\ 16^m\ 45^s$, long. per moon and ∗ Antares 54° 41¼′. Moon, 10th July, *nautical time* (9th mean time), commences cloudy weather. At 3.30 P.M. was alarmed by the officer on deck calling out 'Land a-head!' I ran up from below, and there, to my astonishment, saw what appeared to be the land, about two miles distant, the vessel sailing seven to eight miles per hour. We took in all staysails and stood to the south, wind east-south-east, which might have occupied six or eight minutes to accomplish, in which all appearance of land had subsided. So strongly the appearance of land did this phenomenon assume, that even the Irish passengers saw it, or believed they saw it; and I have a perfect recollection of one of them calling down the hatchway to his comrades, 'Arrah, by Jasus, boys, here's the land close-to.' Every seaman on board saw it, and would have sworn it was the land, had they not been convinced to the contrary by the course steered. I had some difficulty to convince two gentlemen that were passengers that it was not the land, nor were they altogether assured until we saw Barbadoes. At noon, lat. by log 14° 28′, by observation 14° 57′; long. by chronometer 57° 42′, by observation 57° 14′; current 29 miles north; north point of St. Lucia, south 75° 32 west; 188 miles.

(Signed) "J. MONDEL, JUN."

"1, King Street.

The barometer, within the tropics, fluctuates very little except at the time of hurricanes: even during the rainy season, when the atmosphere contains much aqueous vapour, it is not much affected.

But we seem to have a new cause for its fall from the rapid rotatory motion

of a column of the atmosphere in storms: and it will be seen by the following records here given that the fall is always greatest at the centre of the storm. All the observations seem to show that the centre has passed when the barometer begins to rise; and when the wind has sufficiently abated to enable a ship to make sail, she may then bear away without fearing a return of the same storm. Near the middle of the hurricane, before the barometer begins to rise, all square-sails must be dangerous; for then a vessel is liable every moment to be taken aback.

Electricity. The very great quantity of electric matter which displays itself during a tropical hurricane, is one of its striking peculiarities. In August 1675,* as in 1831, it covered the ground in broad plashes, as well as darting upwards.

The northern part of the island of St. Vincent is covered in a great portion with thick forest. In many parts more than half the trees were killed in 1831, without being thrown down. In 1832 I had many opportunities of inspecting them, and they appeared to have been killed by the vast quantity of electric matter passing off from the earth to the cloud above.

It is, I believe, only in high latitudes and in very dry weather, that electric sparks have been observed to be given off from the human body; and then only on taking off woollen or silken dresses. During the most violent period of the tempest on the night of the 10th of August, 1831, at Barbadoes, two negroes were greatly terrified by this appearance, electric sparks passing off from one of them. This happened in the garden of Coddrington College, where the fact was communicated to me by the Principal, the Rev. Mr. Pindar, on the spot where it occurred.

I insert the following remark by Capt. Colford, of the ship Jane Lockhart, as all observations on the effect of electricity on the magnetic needle are important:

"There is a remarkable circumstance connected with the compass at the approach and during one of these hurricanes. The needle veers about *in every direction:* hence it is that we are not enabled, in many cases, to ascertain the direction of the wind. It appeared as if some electric matter affected it."

As connected with this part of the subject, the narrative of the commander of the Judith and Esther must be read with great interest.

Earthquakes. Mr. Lyell is of opinion that many of the storms called hurricanes, have evidently been connected with sub-marine earthquakes; and any opinion of Mr. Lyell's must have great weight.

* Hughes's History of Barbadoes.

It is certainly possible that in a region subject to earthquakes, a shock might take place whilst a storm was in progress over it.

The town of Savannah la Mar, in Jamaica, was overwhelmed by the sea during a hurricane on the 3rd of October, 1780. It is stated in the 'Annual Register' of that year, that an earthquake was felt during the hurricane, and that the ship Princess Royal was driven on shore by its effect. The desire to investigate this supposed connection of earthquakes and hurricanes, led me to procure copies of the logs of ships of war which were at Jamaica at the time. No ship of war's log makes any mention of such an occurrence. The Princess Royal of 90 guns was lying on that day, during the storm, in Port Royal Harbour and not at Savannah la Mar; but there may have been a merchant ship of the same name. In that storm the Thunderer, Scarborough, Barbadoes, and Victor, ships of war, all foundered at sea: yet it was not equal in violence to the storm which occurred a week after at Barbadoes, on the 10th of October, 1780.

The veering of the wind, as marked on the log of the Princess Royal of 90 guns is, east-south-east—south-easterly—east-south-easterly—south-easterly—south-south-easterly—south—south-south-west.

Port Royal, Jamaica, certainly sunk below the sea at another period, during an earthquake, and when there is no hurricane recorded. From what we know of hurricanes, there is no reason to doubt but that Savannah la Mar was overwhelmed in 1780, by the accumulated water of the sea, raised solely by the power of the wind; and the form of the bay in which that town was situated, would serve to increase the height of this accumulation.

In the hurricane of 1831, the sea was greatly elevated against the north-east side of the island of St. Vincent, rising fully ten feet above its usual mark; and this was supposed to be solely owing to the accumulation of water forced by the wind against the island. If records of former hurricanes be examined, it will be found that such rise has generally been the case.

The two hurricanes traced on Charts V. and VI. produced a similar effect in 1837, on the coasts of Florida and Georgia.

It was asserted by some persons at Barbadoes, in 1831, as usual after a hurricane, that an earthquake had been felt during the storm; but there was no satisfactory proof whatever of such having been the case; and I took great pains to inquire on the spot during the same year, as well as to examine the ruined buildings whilst preparing for their reconstruction.

The following extract from the official despatch of Sir George, afterwards Lord Rodney, reporting the damage to his fleet by the great hurricane at Barbadoes on the 10th of October, 1780, shows that men's minds were prepossessed with the idea that an earthquake must attend a hurricane, although he states in this despatch that the inhabitants did not feel one.

"Nothing but occular demonstration could convince me that it was possible for the wind to cause so total a destruction of an island, remarkable for its numerous and well-built habitations; and I am convinced that the violence of the wind must have *prevented the inhabitants from feeling* the earthquake, which certainly attended the storm."

It is essential towards the successful prosecution of the inquiry into the nature of hurricanes, that they should not be connected with earthquakes without satisfactory proof.

Storms in the southern hemisphere.

A very curious part of this inquiry remains for investigation, whether in south latitudes, storms and hurricanes appear to revolve in the same, or in a contrary direction with those in northern latitudes.

Impressed with the idea that to the south of the equator, in accordance with the regularity Nature follows in all her laws, they will be found to move in a directly contrary direction, I have endeavoured to collect such facts as may interest other persons to prosecute further inquiry into the truth of the supposition.

The reports which immediately follow, respecting the hurricanes of 1818 and 1824, at the Mauritius, have been furnished by Captain Locke Lewis, of the Royal Engineers. This officer had proposed to the commandant of the French island of Bourbon in 1824, that the observations on hurricanes at the latter island and at Mauritius should be kept on similar principles, and compared together: it is now matter of regret this was not accomplished. The answer of the commandant, however, to the application, contains a few remarks on the hurricane of 1824, which will be found below.

It is said that the storms which pass over Mauritius and Bourbon, come from the direction of Rodrigue; that is from the east, and proceed towards the southern end of Madagascar.

If the reports of the Mauritius storms be tried, they will not be found reconcileable with the figure of a whirlwind, turning from right to left, (like those of the North Atlantic) unless their progress be from the westward and towards the east. If they are tried by the other figure, turning from left to

right, supposing yourself in the centre, the veering of the wind will be reconcileable with a progressive whirlwind coming from the east.

The information here printed is, however, far from sufficient. There is only enough to excite interest for further inquiry.

"Ouragan à Maurice, du 28 Février au soir, au 1 Mars, 1818.

"Les signes auxquel on reconnaît à Maurice l'approche des grandes tempêtes n'ont point annoncé celle-ci. Dans les jours précédens le mercure des baromêtres de la ville était descendu deux fois au dessous de 28 pouces (29·8 English), mais le 28 Février, il avait repris son niveau ordinaire. Seulement dans l'après-midi, le vent se mit à souffler par rafallés variant de l'est-sud-est au sud-est et au sud-sud-est. La force des grains augmenta progressivement jusques à la nuit et cependant peu de personnes conçurent des inquiétudes. Plusieurs fois dans cette saison, des menaces de tempêtes plus caractérisées n'avaient eu aucun résultat fâcheux. Aussi les marins du port, et les habitans des campagnes négligèrent-ils également les précautions que l'on prend d'ordinaire lorsqu'on craint un coup de vent. Peu de navires renforcèrent leurs amarres; aucun habitant ne songea à couper les tiges des manioes pour en sauver les racines. La nuit survint et l'ouragan commença ses ravages. La force du vent toujours croissante, et la descente rapide du mercure dans le baromêtre, ne laissèrent plus de doute sur le fléau dont on allait éprouver les terrible effets.

"Jusques au milieu de la nuit les vents soufflèrent du sud-sud-est, au sud avec une extréme violence. Vers une heure après minuit, ils commencèrent à tourner vers l'est; au point du jour, ils étaient au nord-nord-est et au nord; le mercure était descendu à 26 pouces 4 lignes (28·00 English), hauteur réduite à celle du niveau de la mer. Jamais on ne l'avait vu aussi bas. Plusieurs personnes crurent que leurs baromêtres etaient dérangé, celles qui ne pouvaient se méprendre sur la cause de cette dépression, s'attendaient à une grande catastrophe. Heureusement pour la colonie que cet état de l'athmosphère, n'eut qu'une courte durée. En effet on peut juger, par le mal qu'a fait l'ouragan, de celui qu'il aurait produit si sa violence, telle qu'elle était, de 4 heures ½ à 6 heures du matin, se fût prolongée de quelques heures. En passant au nord-ouest, le vent se calma assez promptement; le mercure remonte avec toute la rapidité qu'il avait mise à descendre, et dans le journée même du premier Mars, on parvint à communiquer avec la plupart des vaisseaux échoués dans la rade, et l'on put s'occuper de porter quelque remède aux accidens causés par la tempête, à ceux du moins qui en étaient susceptibles.

"On à observé le lendemain du coup de vent que les eaux avaient partout un goût saumâtre. La pluie, pendant sa durée, avait elle-même une saveur très-salée.

"La salle de spectacle est un très-grand édifice. Sa forme est celle d'un T dout la tête est un avant-corps considérable, puisque la partie postérieure, formant la quelle du T, à seule 53 pieds de largeur sur 82 de long. Si cet édifice eût été brisé par la tempête on aurait pu attribuer cet événement à la manière dont il était construit; mais, à qui est à-peine croyable, cet immense arrière-corps de 34 pieds et surmonté d'un comble en charpente, lié en outre avec l'avant-corps qui forme la façade, à cependant chassé de près de cinq pieds sur son

soubassement. Quelle force prodigieuse que celle qui à pu produire, le déplacement horizontal d'une telle masse! son renversement eut été un phénomène ordinaire; sa translation, si l'on peut employer ce terme, ne se conçoit pas.

" Toutes les maisons couvertes en bardeaux *(shingles)* et c'est la presque totalité de celles de la colonie, ont été inondées intérieurement par la pluie. On n'imagine point la violence et l'abondance avec laquelle elle est lancée horizontalement pendant nos tempêtes. Alors les couvertures imbriquées sont inutiles et dangereuses même car elles donnent aux vent une grande prise, et contribuent à la destruction des édifices. Si l'ouragan eut duré jusques à midi seulement avec la même-force la ville n'eut été qu'un monçeau de ruines. Déjà, au moment où il à cessé beaucoup de belles maisons, intactes en apparence, étaiént entamées par le toit. Celles qui n'auraient pas été renversées, eussent été emportées pièce à pièce.

" Les maisons couvertes en terrasses ou argamasses, à la manière de l'Inde, ont résisté à la tempête, et on y a été à l'abri de la pluie. Mais aucune sorte de couverture n'a mieux soutenu cette épreuve décisive que celle construites suivant le procédé de M. Chaix, c'est-à-dire en briques unies par un ciment résineux de sa composition.

" Les couvertures en ardoises ont été enlevées. La plupart de celles en cuivre et en ferblanc ont été enlevées aussi, et cependant les toîts de cette dernière sorte ont sur les bardeaux l'avantage inappréciable de ne point donner de gouttières ou d'être facile à réparer. Le mal est venu de ce qu'on n'avait pas pris les moyens convenables pour les fixer sur le lattis des combles.

" Autrefois les habitans aisés construisaient une petite maison servant habituellement de dépendance, mais destinée surtout à leur servir de réfuge pendant les coups de vent. Quoiqu'il soit probable qu'un fléau pareil à celui du 1 Mars, ne se reproduira pas de longtemps, on ferait bien de revenir à cette sage précaution. Un petit pavillon en pierre soigneusement bâti, peu élevé sur le sol, et couvert d'un toît plat étroitement lié à la maçonnerie, ne coute pas beaucoup plus que construit à la manière ordinaire, et il à le double avantage d'une durée indéfinie, et d'être un lieu de sureté, pour les familles lorsque l'ouragan se déclare."

Log of H.M.S. Magicienne, commanded by Captain PURVIS, R.N. Mauritius, Feb. 28, 1818.
This Log is in *Civil Time.*

Hour.	Wind.	Bar.	Ther.	Remarks.
				February 28, 1818.
P.M.	S.S.E.			Wind S.S.E.; P.M. fresh breezes and squally, heavy rain at times; at 3 sent party on board the Agile (a detained schooner) to take her lower yards and topmasts, and secure her afresh; observed a chasse-marée upset in the middle of the harbour, sent the barge to her assistance; at 6 a pilot came on board, in consequence of the fall of the barometer, and threatening appearance; at 8 squally; at 12 midnight, strong gales, heavy squalls.
	Squally	fall		
				March 1, 1818.
A.M.	S.S.E.			Wind S.S.E.; A.M. 2.10 strong gales, heavy squalls, and rain, blowing excessively hard; the best bower bent to a mooring anchor; ship driving slowly; got the spars out of the rigging; S.E. at 2.40 a merchant ship drove athwart us, and carried away the jib and flying-jib-boom, with gear, then went clear and upset; at 3 a schooner drove athwart us, remained some time, and
	S.E.			

Log of H.M.S. Ship Magicienne—*continued.*

Hour.	Wind.	Bar.	Ther.	Remarks.
A.M.	S.E.			then drove on shore; at 4 blowing a complete hurricane, ship still driving; drove on board the Prince Regent, merchant ship; carried away the ensign staff, and cut the stern down to the cabin windows; carried away her jib-boom, and sprung her bowsprit; jolly-boat swamped and went down; the barge went adrift, and stove her broadside in with the Prince Regent's anchor; made fast a cable to the careening hulk; ship aground; heeling very much to port; E.S.E. at 5 a brig drove athwart us; carried away her mainmast, and went on shore; daylight, hurricane still unabated; observed all the ships in harbour (except the American brig Jason,) forty-one in number, were either on shore or sunk; found the main and mizen channels shifted with the violence of the wind, and the hammock cloths, rails, and boards blown away; at 6 parted the sheet cable; the hulk parted her mooring-chains, and [illegible] drove on shore at the point of the entrance of the fort; N.E. ship heeling very much to starboard; sounded round the ship, and found ten feet water from the fore to the main-chains, seventeen feet under the stern, and eighteen feet under larboard bow; at 8 hard gales with heavy squalls and rain; issued a gill of spirits to ship's company; at 9 more moderate; noon, strong breezes and squally; found as the weather moderates *the water shoaled* fast; under starboard fore-chains only seven feet, astern fourteen, and [illegible] the larboard bow fifteen feet; N.E. between 2 and 3 P.M., fresh gales and squally with rain; at 4 fresh breezes and rainy weather; attempted to heave the ship off by the single bower, fast to mooring anchor; at 4.30 found anchor coming home; E.N.E. at 7 and 8 fresh breezes, and cloudy weather; easterly at 10.30; midnight moderate with rain.
	E.E.N. Easterly			
				March 2, 1818.
A.M.	E.S.E.			Wind E.S.E. at 8. A.M.

Observations of the State of the Barometers during a Hurricane at the Mauritius, on the 23rd February, 1824.

Hour.	No. 1.	No 2.	No. 3.	Remarks.
At 7. 0 A.M.	29.75	29.77	29.50	Wind S.E.; variable to the E.; strong gales.
8. 0 ,,	,, 75	,, 77	,, 50	Ditto Ditto
8.30 ,,	,, 70	,, 73	,, 50	Ditto Ditto
9. 0 ,,	,, 70	,, 73	,, 50	Ditto Ditto
9.30 ,,	,, 68	,, 70	,, 50	Ditto Ditto
10. 0 ,,	,, 68	,, 70	,, 50	Ditto Ditto
10.30 ,,	,, 63	,, 68	,, 47	Ditto Ditto
11. 0 ,,	,, 63	,, 65	,, 47	Ditto Ditto
11.15 ,,	,, 60	,, 62	,, 45	Ditto Ditto
11.30 ,,	,, 56	,, 58	,, 40	Wind shifted to the eastward.
11.45 ,,	,, 56	,, 58	,, 40	Ditto
12. 0 ,,	,, 53	,, 56	,, 38	Ditto
12.15 P.M	,, 49	,, 50	,, 33	Ditto
12.30 ,,	,, 44	,, 48	,, 28	Ditto
12.45 ,,	,, 40	,, 42	,, 25	Wind E.N.E.
1. 0 ,,	,, 37	,, 40	,, 20	Ditto
1.15 ,,	,, 30	,, 34	,, 18	Ditto
1.30 ,,	,, 29	,, 34	,, 16	Ditto
1.45 ,,	,, 25	,, 28	,, 10	Ditto
2. 0 ,,	,, 20	,, 22	,, 5	Ditto
2.15 ,,	,, 11	,, 13	28.95	Ditto
2.30 ,,	,, 11	,, 13	,, 95	Ditto
2.45 ,,	,, 2	,, 5	,, 88	Ditto
3. 0 ,,	28.97	28.99	,, 80	Wind N.E.
3.15 ,,	,, 85	,, 83	,, 69	Ditto
3.30 ,,	,, 75	,, 77	,, 60	Ditto
3.45 ,,	,, 66	,, 69	,, 52	

Observations of the State of the Barometers—*continued.*

Hour.	No. 1.	No. 2.	No. 3.	Remarks.
At 4. 0 P.M.	28.58	28.60	28.45	Wind N.N.E.
4.15 ,,	,, 58	,, 60	,, 45	Ditto
4.30 ,,	,, 59	,, 60	,, 46	Wind North
4.45 ,,	,, 59	,, 60	,, 47	Wind N.N.W.
5. 0 ,,	,, 59	,, 60	,, 47	Wind N.W.
5.15 ,,	,, 62	,, 60	,, 47	Ditto
5.30 ,,	,, 67	,, 60	,, 53	Ditto
5.45 ,,	,, 67	,, 60	,, 53	Ditto
6. 0 ,,	,, 72	,, 71	,, 59	Wind W.; gale decreasing.
6.15 ,,	,, 86	,, 83	,, 73	Ditto Ditto
6.30 ,,	,, 97	,, 94	,, 80	Ditto Ditto
7. 0 ,,	29. 9	29. 6	28.90	Wind S.W.
7.30 ,,	,, 17	,, 14	29. 0	Ditto
8. 0 ,,	,, 28	,, 23	,, 8	Wind S.E.
8.30 ,,	,, 33	,, 30	,, 16	Ditto
February 24				Wind S.W.
6. 0 A.M.	,, 67	,, 60	,, 46	Ditto
7. 0 ,,	,, 69	,, 62	,, 49	Ditto
8. 0 ,,	,, 70	,, 66	,, 50	Wind W.
				(Signed) THOMAS LOCKE LEWIS, Captain, Royal Engineers.

In the hurricane of the 23rd of February, at the Mauritius, upwards of thirty vessels were wrecked there.

The following remarks, printed in a Mauritius newspaper, relate to the manner in which the wind appears to blow in veins differing in degrees of strength:

" Il parait qu'une trombe, ou tourbillon (de ceux qui ont fait donner aux ouragans le nom de typhon,) à parcouru une ligne sur laquelle se sont trovées plusieurs maisons du Champ-de-Lort, et particulierment le College Royal.

" C'est contre ce terrible phénomène, qu'il faut se précautioner dans les ouragans: aussi n'est il pas prudent en pariel cas, de demeurer dans les maisons élevées; dans celles surtout qui sont posées sur de haut soubassemens en pierre formant le rez-de-chaussée. C'est tres mal raisonner que de dire, qu'une maison a résisté à tel ouragan ou à tel autre. Elle ne s'est pas trouvée sur le chemin d'un tourbillon, voilà ce qui l'a preservée. Telle est aussi la cause d'un fait observé dans tous les ouragans celui de la préservation d'une maison tombante de véstuté, étroite, élevée, qui n'est pas même ébranlée à peu de distance d'un édifice neuf, qui est renversé ou mis en pièces.

" La météorologie est encore dans son enfance. Tout-ce-que nous savons c'est que, dans ce qu'on appelle les mauvais tems, la pesanteur des colonnes atmosphériques decroit plus ou moins; mais les proportions entre ce décroissement, et l'action de l'air à la surface de notre planête, demeureront probablement long-temps ignorées. Probablement aussi ce n'est pas nous qui verrons construire l'anémomêtre capable de mesurer la force acquise par l'air, l'orsqu'il *réduit en filamens*, et qu'il tord comme un cordage le tronc d'un arbre vigoureux, ou qu'il fait tourner sur sa base, une édifice en pierre comme la Maison Laffargue. Aussi les diverses denominations données récemenent aux différens dégrés de la tempête, en raison de l'espace que le vent parcourt dans une seconde, nous semblent t'elles fort insignificantes. C'est le tort de beaucoup de savans. Ils ont la fureur de réduire prématurément en théories certains points des sciences naturelles, sur lesquelles on est entièrment dépourvu de faits suffisamment observés. " J. M."

Copy of a Letter from the Commandant of the Island of Bourbon, to Captain T. Locke Lewis, Royal Engineers, relative to the hurricane of the 23rd of February, 1824:

" Nous avons ressenti à Bourbon, le contre coup de votre tempête. Il est à remarquer, que le 22 Février, nous eûmes aussi des apparences de mauvais tems; qui s'accruerent jusqu'au lendemain, au point de me déterminer, à donner le signal d'appareillage à nos batimens, Mais ces doux jours, les vents resterent à l'est et ▬ sud-est ils s'appaiserent dans la journée même du 23. Le lendemain le tems fut magnifique, et se maintint en cet état, jusque dans l'après midi du 25, que le vent s'étant déclaré au nord, amena des nuages, et une simple apparence de pluie. L'indication barométrique, n'était nullement défavorable. Par malheur les batimens étoitent revenues sur la rade; dans la nuit la mer devint affreuse, et contribua surtout, à en pousser neuf d'entre eux, sur la côte. Le vent souffla alternativement du nord, et du nord-ouest; mais sans une extrême violence. Le baromêtre etoit descendu alors à per long. 27° 7′ (or 28° 2′ English.)

There was a severe hurricane at Mauritius on the 19th and 20th of January, 1834. Mr. James Tilly, who commanded the merchant ship Emma Eugenia, states, " that the wind was from the east, veering to southward, and that his ship, with seventy-nine other vessels, was driven on shore." He describes the wind as coming " in sudden gusts." It would be desirable to obtain further information from Mauritius of this storm.

Another storm was experienced at Mauritius on March 6, 1836; during which, according to the statement of Captain Grierson, R. E. (made from memory,) " the wind blew, during the first half of the storm, from south by west, or nearly south. There was a calm of about an hour in the middle of the storm, after which a very heavy sea came rolling in from the north by east, or nearly north; half an hour after which occurrence, the wind came on again from the opposite quarter with very great violence."

In the Nautical Magazine for June 1837, the following report has been published of observations which were made during the storm by the Surveyor-General of Mauritius, at the Observatory, apparently with great care. The wind in that table is marked as oscillating in a remarkable manner. A mean of these oscillations makes the first portion of the hurricane to come from a little of the eastward of south, and the last portion a little to the westward of north, or nearly the same as the observations of Captain Grierson.

Immediately over Port Louis, where the Observatory stands, is a high and steep mountain, which probably influenced the direction of the gusts of wind. If this hurricane came from the direction of Rodrigue, as it is alleged the storms do come to Mauritius, it will be found on trial that it could not have revolved in the same direction with those of the North Atlantic; but it will be reconcileable with the other figure, which revolves like the hands of a watch, from left to right.

Meteorological Observations taken at the Observatory, Port Louis, Mauritius, during a Hurricane on the 5th, 6th, 7th, and 8th of March, 1836.—(*Copied from the Nautical Magazine for June* 1837.)

Day.	Hour.	Barometer, English Inches.	Difference.	French Inches, and Lines.	Thermometer.	Sympiesometer.	Rain Gauge.	Wind.
							I. T. H.	
5th	8	29·930	...	28 1·00	82·0	29·14	0 0 0	Light wind.
	12	29·850	080	28 0·10	83·0	29·05	...	Very variable, and blowing hard, wind varied from S. b. W. to E.N.E. b. N.
	4	29·740	110	27 10·86	83·5	28·94	...	S.E. very strong, E.S.E. by S. to S.S.W. by S.: raining.
	7½	29·770	030	27 11·19	82·8	28·98	...	S.E. very strong, and in gusts, S.E. by E. to S.W. by S.: raining.
	8	29·770	...	27 11·19	82·6	28·98	...	E.N.E. ditto, ditto, N.E. by N. to S.S.W.: raining heavily.
6th	6	29·220	550	27 5·00	81·5	28·44	...	Varying from S. to E. in very strong gusts. Made a complete variation during the night: raining heavily.
	6½	29·190	030	27 4·66	81·5	28·42	...	Varying from S. to E. in very strong and sudden gusts: raining heavily.
	7	29·175	015	27 4·44	81·5	28·40	...	Varying from N.E. by N. to S.S.W. by W., in heavy and sudden gusts: still ditto.
	7½	29·175	...	27 4·44	81·5	28·40	...	A complete variation in heavy and tremendous gusts: raining heavily.
	■	29·120	055	27 3·88	81·5	28·34	...	Varying from E.N.E. by N. to S.W. by W., in heavy and continued gusts: raining heavily.
	8½	29·110	010	27 3·76	81·5	28·34	...	Varying from E. by N. to W.S.W., in heavy blasts: still raining.
	9	28·995	115	27 2·53	80·5	28·25	...	Varying from E.N.E. by N. to S.S.W. by S., in heavy and sudden puffs: raining very heavily.
	9½	28·950	045	27 1·96	80·2	28·22	...	A complete variation in heavy and sudden gusts: still raining heavily.
	10	28·845	105	27 0·72	80·0	28·15	...	A complete variation: still blowing in heavy and sudden gusts, and heavy rain.
	10½	28·860	015	27 0·95	80·0	28·12	...	Varying from N.E. by N. to S.W., in sudden and heavy gusts: raining heavily.
	11	28·775	085	26 11·95	79·5	28·04	...	Varying from E.N.E. by N. to S.W., in sudden and heavy gusts: ditto.
	11½	28·695	080	26 11·03	79·0	27·93	...	Varying from E.N.E. by N. to S.W., in ditto, ditto: still raining.
	12	28·545	050	26 9·35	79·0	27·84	...	Varying from E.N.E. by N. to S.W., in sudden and heavy gusts: ditto, ditto.
	12½	28·511	034	26 9·01	79·5	27·78	...	Varying from E.N.E. by N. to S.W., in ditto, ditto: still raining.
	1	28·470	041	26 8·56	79·8	27·72	...	Varying from E.N.E. by N. to S.S.W. by W.: still in heavy gusts, and raining.
	1½	28·375	095	26 7·43	79·8	27·60	...	Varying from E.N.E. by N. to S.S.W. by W.: still high, and raining.

Meteorological Observations—*continued.*

Day.	Hour.	Barometer, English Inches.	Difference.	French Inches, and Lines.	Thermometer.	Sympiesometer.	Rain Gauge.	Wind.	
							I. T. H.		
6th	2	28·330	045	26 6·98	80·2	27·52	...	Varying from N.E. to S.W., decreasing in violence, and raining less heavily.	
	2½	28·295	035	26 6·53	80·5	...	...	Varying from E.N.E. by N. to S.S.W. by W., in occasionally heavy puffs.	
	■	28·245	050	26 5·97	80·5	...	...	Varying from E.N.E. to S.S.W., in ditto, ditto.	
	3½	28·275	030	26 6·30	80·5	...	...	Varying from E.N.E. to S.S.W.: rain and wind decreasing.	
	4	28·255	020	26 6·08	80·5	...	...	Varying from E.N.E. to S. by W.: ditto, ditto.	
	4½	28·240	015	26 5·97	80·5	...	...	Varying from E. by S. to W. by S.: ditto, ditto.	
	5	28·230	010	26 5·85	80·7	...	...	Varying from due S. to due W., very light: raining.	
Calm	5½	28·235	005	26 5·86	81·0	...	...	No wind—no variation.	
	6	22·245	010	26 5·97	81·0	...	...	Varying from due S. to N.N.E. by E., very light.	Calm.
	6½	28·255	010	26 6·08	81·3	...	...	N. by W., almost calm: wind varying from N.W. by N. to N. by E.	
	7	28·275	020	26 6·30	81·0	...	...	Varying from N.E. to N.N.W. by W., cloudy and calm.	
	7½	28·325	050	26 6·87	81·0	...	...	W. by S. to N. by W., very cloudy, and blowing.	
	■	28·420	095	26 7·99	80·2	27·69	...	Varying from S.W. to N.W. by N., very cloudy, and blowing.	
7th	7	29·355	935	27 6·47	79·0	28·77	...	Varying from N. by E. to W.S.W. by S., blowing hard, and raining heavily.	
	7½	29·385	030	27 6·80	79·0	28·81	...	Varying from W.N.W. to N. by W., blowing hard, and raining heavily.	
	■	29·400	015	27 7·03	79·0	28·82	...	Varying from W. by N. to N. by W., blowing hard, and raining heavily.	
	8½	29·410	010	27 7·14	79·0	28·83	...	Varying from W.N.W. to N.N.W., blowing hard, and raining heavily.	
	9	29·445	035	27 7·48	78·6	28·86	...	Varying from due W. to due N., blowing hard, and raining heavily.	
	9½	29·450	005	27 7·59	79·5	28·86	...	Varying from due W. to due N., blowing hard, and raining heavily.	
	10	29·460	010	27 7·70	79·0	28·86	...	Varying from due N. to W.N.W., blowing hard, and raining heavily.	
	10½	29·460	000	27 7·70	79·0	28·86	...	Varying from N. by W. to N.W., blowing hard, and raining heavily.	
	1	29·468	008	27 7·82	78·7	28·87	...	Varying from due W. to due N., blowing hard, and raining heavily.	
	1½	29·480	012	27 7·93	78·5	28·88	...	Varying from due W. to due N., not quite so high.	
	2½	29·525	045	27 8·38	78·5	28·92	...	Varying from due W. to due N., not quite so high.	
	4½	29·550	025	27 8·72	78·5	28·96	...	Varying from due W. to due N.: wind decreasing, but still in heavy blasts occa-	
	6½	29·595	045	27 9·17	78·5	29·01	...	Ditto Ditto [sionally.	
	7½	29·835	240	27 11·87	78·5	29·24	8 6 7	Varying from S.W. to N. by W.	
8th	12	29·845	010	27 11·98	81·0	29·23	...	Varying from W.S.W. to N.N.W.	
	4	29·845	000	27 11·98	81·0	29·23	...	Varying from W. by N. to W. by S.	
	8	29·935	090	28 1·0	80.0	29·34	...	Varying from N.W. to S.W.	

Extreme variation during the gale of the Barometer—English, 1·700 in.; French, 1·7·15 in.

J. A. LLOYD, Surveyor-General and Civil Engineer.

Whilst concluding this paper, I received from Mr. Redfield of New York copies of the pamphlets he has printed on the subject of storms. In one of these, published in 1835, he states, "The journals of voyages and other published records, when examined and collated, are deemed sufficient to afford decisive evidence that a system of the same general character prevails in the southern hemisphere, but exhibiting for the most part precisely counter-movements." This is in accordance with the opinion expressed above.

Should it be proved that the Mauritius hurricanes exhibit counter-movements to those in north latitude, they might furnish us with some explanation of the great swell of the sea at the Cape of Good Hope. But although the storm tracks in the Bay of Bengal and the Malabar coast are too important not to be alluded to, it is impossible to enlarge on the subject in an article already too extended; neither is there space here to consider whether the storms of the tropics entirely lose their rotatory character before reaching our own shores. It is to be hoped, the observations made at our light-houses will furnish data for the inquiry; and if the subject should interest sufficiently, that these observations may be connected with others made by different nations. Were the logs of packet ships to be collected and arranged, they would be a great means of assisting this inquiry.

There is no doubt that the greatest hurricane in West Indian history, that of October 10, 1780, was of the same rotatory character as these here described. The interest I have felt in the investigation has led me to procure sufficient information to trace this tempest in its course; and I propose to explain it, in a separate work, in the hope of drawing attention to further inquiry on these subjects.

The details of that great storm will furnish ample testimony (if any be wanting) that precautions unnecessary in the latitude of England, in constructing buildings, are peremptorily demanded in countries subject to the ravaging effects of tropical hurricanes.

The Officers of Engineers are serving in all climates, and are extended from Van Dieman's Land to Canada. If they had an opportunity of seeing the different meteorological instruments in use at the commencement of their career, they might render essential service by furnishing useful observations; and the expense to the public would probably be much more than repaid, if a complete set were placed at the Practical School of Instruction.

ERRATA.

At page 139, in wood-cut, *for* S.E. *read* S.W.;—page 155, line 8, *for* 30th August *read* 30th July.

XVI.—*On the Fact of Small Fish falling during Rain in India.* By Captain C. W. Grant, *Bombay Engineers.*

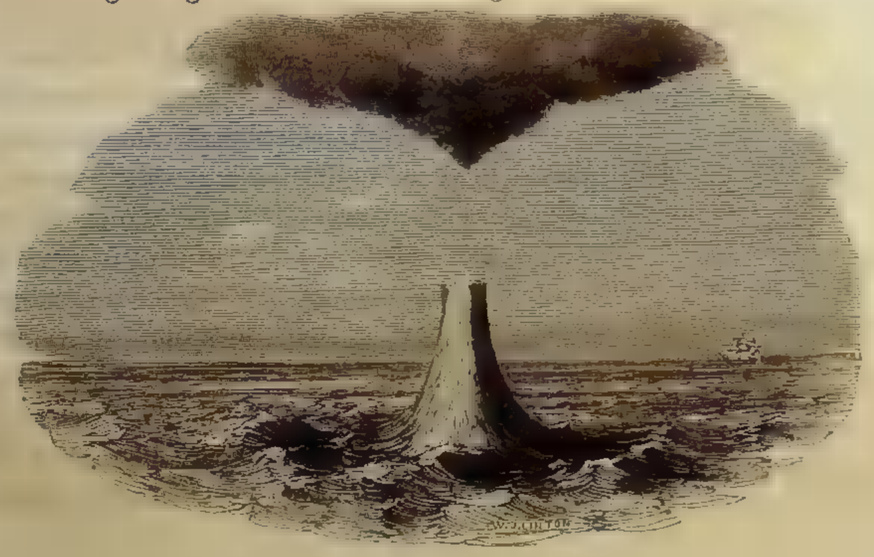
That such is the case is certainly the generally received opinion; and I have met with many officers who profess to have themselves witnessed the fact; that is, that after a heavy fall of rain, they have seen small fish jumping about on the terraced roofs of houses, and in other places wholly inaccessible to them, unless they had fallen from the clouds; but I never knew any one who had either caught them in a water-tub or other reservoir, or had known them to fall on his person, as we have a right to expect would have sometimes occurred, if such were the case; or that in fact would affirm, that he had actually seen them *falling*.

I have myself frequently noticed little fish flapping about in puddles on the top of a high table land, during and after heavy rains; but think their presence in such places, as well as on terraces, may be accounted for, without resorting to so improbable an hypothesis as that of falling from the clouds.

In most parts of India, the beds of small rivers, as well as those of the tanks or natural ponds, which are so numerous in the rainy season, become dry during the hot months, so that the small fish with which they abound must all perish, either from this cause, or by means of the numerous water-fowl and other enemies, to which they become an easy prey; so that unless their spawn had the power of retaining its vitality under very untoward circumstances, it would be difficult to account for their re-appearance every season in such numbers; and that the spawn has this power there are many reasons for believing: among others, it is even said that some water-fowl, who subsist on this substance during their migrations, void the spawn two or three days afterwards, the eggs retaining their vital functions unimpaired.—(See Lyell's 'Principles of Geology.') It is, therefore, very probable that this spawn may adhere to pieces of stick or grass floating in the tanks or rivers, which on their becoming dry are borne aloft by the small whirlwinds, or *devils* as they are are called in India, and thus carried through the air for a considerable distance, and lodged either on the terraces of houses, or on any other apparently inaccessible places (or the spawn may in itself be drifted along, mixed with the sand of the dried up river beds); here they are swept by the eddy into the corners, gutters, or other protected spots, where they remain

until washed out by the first fall of rain, which frequently lasts for many days. And when we consider how rapidly generation takes place in tropical latitudes, it is easy to suppose these little fish or fry might appear in such unlikely places. The constant heat of the atmosphere from the time of the drying up of the tanks, &c. (that is, during the hot months of April and May,) till the first fall of rain, may perhaps account for the spawn or eggs retaining their vitality under such apparently unfavourable circumstances.

The small whirlwind, or devil above alluded to, has such power that it frequently unroofs a house, carrying the thatch a great height into the air, as well as pieces of paper, matting, or any light substance; and frequently assumes the appearance of a large and lofty pillar of sand, moving at a steady pace across the plains, sucking every thing of small weight up into its vortex, and thus sweeping along for miles, being evidently acted upon by two distinct forces, a spiral motion round its own axis, and a progressive or linear impulse; and might therefore possibly draw up these small fish into the air (as has been suggested by some), whence they would fall with the rain: but as these devils occur chiefly, *solely* I believe, in the hot winds or dry season, and never during a fall of rain, such a mode of accounting for their appearance loses its weight; though I admit that these peculiar currents of air may pass over the sea as well as the land, having myself seen the ocean affected in a manner that could only be occasioned by some such cause, namely, the surface drawn up in an irregular conical form to a considerable height, the clouds bellying down as it were to meet it, and the whole advancing in a given direction, assuming somewhat this appearance:—



The space between the clouds and the water being very strongly marked, so that it is just possible that a shoal of small fish swimming near the surface might be lifted out of the water by such a cause; but as they have been said to fall in the interior of Hindoostan, in places immensely distant from the sea, and at a time when the tanks, &c. are mostly dried up, such an explanation of the fact is beset with difficulties.

The late Major Hawkins of the Bombay Engineers, who built and put up the machinery of the Mint at that Presidency, told me that he had paid much attention to this subject, but that he had never met with any person who believed in the idea of these fish falling from the clouds, who did not, on further inquiry, admit facts that enabled him (Major H.) to account for their presence in a more probable manner; his idea being, that the fish generally contrived to work themselves up to these apparently inaccessible places, such as the terraces of houses, &c., by means of the pipes or gutters by which the water is let off them, or by the angles or corners of the buildings; it being well known that fish have an extraordinary power of surmounting obstacles to their progressive movements, as is evinced by the salmon and other species, particularly the young of eels, who are said to be enabled to climb over the gates of a lock, even when dry, by means of the slime on their bodies.

Be this as it may, I still think that either this explanation, or that which I have here suggested, is more consistent with our knowledge of nature and her laws, than that these small fish should actually fall from the clouds; though, I believe, we are in a minority on the subject, the fact of their actually falling with the rain being the more generally received opinion.

Since writing the above, my attention has been called to a paper in the 'Journal of the Asiatic Society' of Bengal, for December 1833, which bears so directly upon this subject, that I am induced to transcribe it, from an idea that it may not have come under the notice of many of the readers of this work.

It is written by James Prinsep, Esq. the editor of the journal in question, and is headed, "Fall of Fish from the Sky."

"The phenomenon of fish falling from the sky in the rainy season, however incredible it may appear, has been attested by such circumstantial evidence, that no reasonable doubt can be entertained of the fact. I was as incredulous as my neighbours, until I once found a small fish, which had apparently been alive when it fell, in the brass funnel of my pluviameter, at Benares, which stood on an insulated stone pillar, raised five feet above the ground in my garden. I have now

before me a note of a similar phenomenon, on a considerable scale, which happened at Nakulhatty Factory, Zillah Decca Jelalpoor, in 1830.

" Mr. Cameron, who communicated the fact, took the precaution of having a regular deposition of the evidence of several natives, who had witnessed the fall, made in Bengalee, and attested before a magistrate : the statement is well worthy of preservation in a journal of science, I therefore make no apology for introducing a translation at length. The shower of fish took place on the 9th February, 1830, in the neighbourhood of the Surbundy Factory, Feridpoor.

JAMES PRINSEP.

The depositions of eight or ten people here follow, of which I shall merely give extracts.

Shekh Chandhari Ahmed relates in his deposition, " I had been doing my work at a meadow, when I perceived at the hour of 12 o'clock the sky gather clouds, and it began to rain slightly, then a large fish, touching my back by its head, fell to the ground. Being surprised, I looked about, and behold a number of fish likewise fell from heaven! They were, *saul*, *sale*, *yugal*, *mingal*, and *badul*. I took ten or eleven fish in number, and I saw many other persons take many. I looked at heaven, and I saw like a flock of birds flying up, but there my perceptions were not clear enough : amongst these fish many were found rotten, without heads, and others fresh and perfect; and amongst the number which I had got, five were fresh, and the rest stinking and headless."

Shekh Punikulloh, twelve years of age, declared, " while I was sitting in my own house, I perceived a number of fish fall from the sky, some of them on the roof of my own cottage, one of them was large, about *one cubit;* and *three seer* (*lb.*) *in weight*."

Another man says, " I perceived a baduli fish, large, about *one cubit*, fall before me from the sky, after which I went further and found another."

Another says, " I observed a *mingal*, and some other fish, *badulis*, &c. of different sizes fall from the sky; I picked up about five or six of them to satisfy my curiosity, but did not eat them at all."

Another man deposed, " I found every part of my hut scattered with fish; they were *baduli*, *mingal*, and *nauchi*, and amounted to twenty-five in number."

Again, " some were fresh, but others rotten, and without heads."

All accounts agree as to the time, 12 o'clock, and as to the description of fish.

With regard to the small fish that Mr. Prinsep found in his pluviameter, I think its presence is as likely to have been occasioned by either of the causes before mentioned, as that it fell from the clouds; but with respect to the circumstantial account of the fall of fish in the neighbourhood of Feridpoor, I have nothing to say. When we read of fish, a *cubit in length*, and *three pounds in weight*, falling from the sky, some fresh, others putrid, and without their heads, our reason is at fault, unless we suppose them to have been thrown up by some volcanic or gaseous eruption, such as is I believe mentioned by Humboldt as having occurred in South America : but it is quite evident that such a phenomenon can have no connection with the fact of small fish commonly falling during rain in India; though I beg to state, that my suggestions as to the cause of their appearance in apparently inaccessible spots are offered with the greatest diffidence, having been induced to give them solely with the hope of exciting discussion and information on this certainly interesting fact, as before we can arrive at a proper understanding of the subject, it would be necessary to learn from repeated observations, whether the fish that fall are of fresh water or marine species, and whether they are full grown specimens of a small class, or the fry of larger kinds; what the direction of the wind was at the time of their falling, as well as any peculiarity of atmosphere as denoted by the barometer or thermometer, and other minutiæ that will naturally occur—my aim in writing these few remarks being chiefly to detail the effects of those small whirlwinds called devils, that sweep across the Indian plains, and to show that they may be considered as models of those mighty hurricanes, that it has been the object of the foregoing paper to describe.

C. W. GRANT,
Captain, Bombay Engineers.

March 1838.

XVII.—*Instructions for Making and Registering Meteorological Observations at various Stations in Southern Africa, and other Countries in the South Seas, as also at Sea.* By Sir John F. Herschel, K.H., F.R.S.

The foregoing paper on hurricanes by Lieutenant-Colonel Reid, is of so interesting a character, and presents so many inducements to the close and systematic observation of atmospheric phenomena, that I have considered myself justified in reprinting, for the information of the officers of the Corps, the instructions for making and registering meteorological observations, drawn up by Sir J. F. Herschel for the South African Literary and Philosophical Institution. These instructions have a general character, and apply to every country and every climate: there are a few observations which bear more particularly on the colony of the Cape of Good Hope; but I have not thought it necessary to make any alteration on that account, but have reprinted the whole exactly as it came into my hands.

The necessary duties of the Officers of the Corps of Engineers require their presence in all our colonies; scattered therefore in every quarter of the globe, no men have better means of making the necessary observations; and I trust that many years will not elapse, before the collection of a mass of meteorological facts will bear testimony to their industry, and their zeal for the advancement of science.

W. D.

The great importance of possessing an exact and carefully registered account of the variations of the barometer, thermometer, and other meteorological instruments, and of the winds and weather, throughout that extensive region of the southern hemisphere, which is either included within the boundaries of this colony,* or readily accessible from it, has determined the South African Literary and Philosophical Institution to request the assistance of its

* Cape of Good Hope.

correspondents, and of all who may have leisure and inclination for observations of the kind, towards the gradual accumulation of a continued and extensive series of Meteorological Journals, and towards carrying into effect a concerted plan of contemporaneous observations, on stated days, from which it is conceived that much advantage will be derived. The institution therefore solicits the attention of its correspondents, and of the lovers of knowledge generally, to this object; and earnestly requests their co-operation in making, arranging, and forwarding to its secretary, resident in Cape Town, observations of the nature, and so far as practicable, according to the plan of those hereafter detailed. Such observations alone can furnish the materials necessary for an accurate and scientific inquiry into the laws of *climate*, regarded as an object of local interest, and are the only data through which (taken in conjunction with the known laws of physics) the more general relations of meteorology can be successfully investigated.

It can scarcely be necessary to insist on the practical importance of this science to the agriculturist, to the navigator, and indeed in every branch of human affairs, or to dilate on the benefits which must accrue to mankind in general, from any successful attempts to subject to reasonable and well-grounded prediction, the irregular and seemingly capricious course of the seasons and the winds; or on the advantages, purely scientific, which must arise from a systematic developement of laws, exemplified on the great scale in the periodical changes of the atmosphere, depending as they do on the agency of all the most influential elements, and embracing in their scope every branch of physical science. It is more to the present purpose to observe that, from what has already been done in this department of human knowledge, there is every reason to hope that no very distant period may put us in possession of the key to many of the most intricate meteorological phenomena, and enable us, though not to predict with certainty the state of the weather at any given time and place, yet at least to form something like a probable conjecture as to what will be the general course of the next ensuing season; perhaps to prepare us beforehand for violent and long continued gales of wind, great drought, or extraordinary wet seasons, &c., in the same manner that our knowledge of the nature and laws of the tides, although confessedly imperfect, and in great measure empirical, yet enables us to announce beforehand, unusually high or low tides. No doubt such predictions of the weather, although only of a probable nature, would be highly valuable and useful, and would materially influence the practice of men in all operations

thereon depending. In illustration of this, we need only refer to the value set by many farmers and others on weather-tables founded on no sound principles, and ratified at best, if at all, only by a very partial and limited experience; or to choose a better instance, we may cite the importance which is now attached by every seaman to the indications of the barometer, and the numerous cases with which nautical records abound, of great mischief, or even shipwreck, avoided by timely attention to its warnings.

Meteorology, however, is one of the most complicated of all the physical sciences, and that in which it is necessary to spread our observations over the greatest extent of territory, and the greatest variety of local and geographical position. It is only by accumulating data from the most distant quarters, and by comparing the affections of the atmosphere at the same instant at different points, and at the same point at different moments, that it is possible to arrive at distinct and useful conclusions.

Hence arises the necessity of procuring regular series of observations made on a uniform system, and comparable with themselves and with each other, by observers at different stations, and of multiplying the points of observation as much as possible over the interior surface of continents, along sea coasts, in islands, and in the open ocean.

The geographical position of this colony renders it perhaps the most interesting and important situation on the surface of the globe, for observations of this nature: first, whether we regard it either as an advantageous station for observing the commencing action of the great counter-current of the trade winds, where it first strikes the earth's surface, and, combined with the action of the heated surface of the African promontory, gives rise to that remarkable alternation of south-east and north-west winds, which forms so distinguishing a feature of our climate; or consider it, secondly, as the furthest extremity of one of the two great lobes of land which form the terrestrial part of our globe, and as such, constituting at once a barrier to the currents and tides of two great oceans, and a limit to their climates; or, lastly, as a great nautical station, and one not devoid of difficulty and danger, in which every consideration of practical interest combines to stimulate the curiosity of the theorist, and give importance to the results of his inquiries.

As these pages may fall into the hands of many who have been little in the habit of observing systematically, or who may not be in the possession of instruments of the nicest construction, attention to the following instructions is recommended as the means of rendering their observations most available for useful purposes, and comparable with each other, and with those intended to be referred to as standards.

1. *General Recommendations and Precautions.*

1. The continuity of observations ought to be interrupted as little as possible by changes in the adjustments of instruments, in their places, exposure, mode of fixing, or of reading off and registering them. Whenever any alteration in these or any other particulars takes place, especially such as are likely to affect the zero points, or otherwise to influence the mean results, it should be noticed in the register.

2. So far as possible registers should be complete; but if by unavoidable circumstance of absence, or from other causes, blanks occur, no attempt to fill them up by general recollection, or by the apparent course of the numbers before and after, should ever be made.

3. The observations should, if possible, all be made by one person; but as this may often be impracticable, the principal observer should take care to instruct one or more of his family how to do it, and should satisfy himself by many trials that they observe alike.

4. The entries in the register should be made at the time of observation, and the numbers entered should be those actually read off on the respective scales of each instrument, on no account applying to them previous to entry any sort of correction; as for instance, for zero, for temperature, capillarity, &c. All these and the like corrections, being matter of calculation and reasoning from other observations, are to be reserved till the final discussion of the series, and for separate determination and statement.

5. If copies be taken of the registers, they should be carefully compared with the originals by two persons, one reading aloud from the original and the other attending to the copy, and then exchanging parts, a process always advisable wherever great masses of figures are required to be correctly copied.

6. A copy so verified, or the original, (the latter being preferred) should be transmitted regularly (if possible monthly from places within the limits of the colony) to the Secretary of the South African Literary and Philosophical Society, at Cape Town; which institution, on its part, will take care that such documents shall not merely be treasured as a dead letter in its archives, but shall

be rendered available towards the improvement of meteorological knowledge, to the full extent of their actual scientific value.

7. The register of every instrument should be kept in parts of its own scale, as read off, no reduction of foreign measures or degrees to British being made; but it should of course be stated what scale is used in each instrument.

2. *Of the Times of Observation and Registry.*

Meteorological observations should be made and registered daily, at stated and regular hours. In fixing on those, some sacrifice of system must of necessity be made to the convenience and habits of the observer. The best hours in a scientific point of view would be those of sunrise, noon, sunset, and midnight, and those are the hours for which the registers are kept at the Royal Observatory. But these are not the hours adapted to general habits; and since the midnight observation is likely to be pretty generally neglected elsewhere than in an astronomical observatory, the following hours, for a division of the day into three parts, are proposed for what may be deemed the morning, afternoon, and evening observations, viz.

Morning, 8 A.M.—Afternoon, 2 P.M.—Evening, 8 P.M.

If however the habits or engagements of any one should not allow him to conform to those hours, rather than not observe he may select his own, specifying only what they are at the head of every page of his register, and adhering steadily to them in practice, only observing to make the extreme observations of each day equidistant from the middle one.

At the same time it will be borne in mind, that in what concerns the great meteorological questions on which the most interesting features of the subject depend, the night is quite as important as the day, and has hitherto been far too much neglected. To any one, therefore, who may feel disposed to enter more zealously into the subject, and will not consider some personal inconvenience ill undergone for the sake of affording data of a peculiarly valuable description, this committee would most earnestly recommend the adoption, in preference to all others, of the quarternary division of the twenty-four hours, as followed at the Royal Observatory above alluded to: and they leave it to the consideration of the council, whether the keeping and transmission of registers on this principle, might not advantageously be distinguished by some honorary reward, as that of a medal for instance, should the funds of the institution admit of it.

With a view, however, to the better determining the laws of the diurnal changes taking place in the atmosphere, and to the obtaining a knowledge of the correspondence of its movements and affections over great regions of the earth's surface, or even over the whole globe, the committee have resolved to recommend that four days in each year should henceforth be especially set apart by meteorologists in every part of the world, and devoted to a most scrupulous and accurate registry of the state of the barometer and thermometer, the direction and force of the wind, the quantity, character, and distribution of clouds, and every other particular of weather throughout the whole twenty-four hours of those days, and the adjoining six hours of the days preceding and following.*

The days they have been induced to fix on and recommend for these observations, are the 21st of March, the 21st June, the 21st September, and the 21st December, being those, or immediately adjoining to those of the equinoxes and solstices, in which the solar influence is either stationary or in a state of most rapid variation: but should any one of those 21st days fall on Sunday, then it will be understood that the observations are to be deferred till the next day, the 22nd. The observation at each station should commence at 6 o'clock A.M. of the appointed days, and terminate at 6 o'clock P.M. of the days following, according to the usual reckoning of time at the place. During this interval, the barometer and thermometer should be read off and registered hourly, or at all events at intervals not more than two hours asunder, and the precise hour and minute of each reading should be especially noted.

For obvious reasons, however, the commencement of every hour should, if practicable, be chosen; and every such series of observations should be accompanied by a notice of the means used to obtain the time, and when practicable, by some observation of an astronomical nature, by which the time can be independently ascertained within a minute or two.† As there is scarcely any

* This is necessary by reason of the want of coincidence of the day in different parts of the globe, arising from difference of longitude. In order to obtain a complete correspondence of observation for twenty-four successive hours over the whole globe, it must be taken into account, that opposite longitudes differ twelve hours in their reckoning of time. By the arrangement in the text the whole of the astronomical day (from noon to noon) is embraced in each series, and no observer is required to watch two nights in succession.

† For example, the first appearances and last disappearances of the sun's upper and lower border, above and below the sea horizon, if at sea or on the coast, or on land, the exact length of the shadow of a vertical object of determinate length on an horizontal level, at a precise moment of time (not too near noon), &c.

class of observations by which meteorology can be more extensively and essentially promoted, it is hoped that, not only at every station of importance in this colony, but over the whole world, and on board ships in every part of the ocean, individuals will be found to co-operate in this inquiry. Every communication of such observations, addressed by channels as secure and as little expensive as possible to the secretary of this institution, will be considered as highly valuable.

3. *Of Meteorological Instruments; and first of the Barometer and its attached Thermometer.*

The barometer is the most important of all meteorological instruments. Its office is to measure the actual pressure of the atmosphere on a given horizontal surface at the time and place of observation. Its fluctuations are observed to have considerable relation to changes in the weather, and especially of the wind: hence its use as a weather-glass.

A barometer should be examined, before setting it up, for air-bubbles in the tube, and for the existence of air above the mercury in the upper part of the tube: this is done by gently inclining the instrument either way from the horizontal position, a little up and down, when air-bubbles, if large, will be seen to run to and fro, and must be evacuated by inverting the instrument, and by gentle blows on it with the hand, driving them up into the cistern. If this cannot be done the instrument is useless. If air exists to an objectionable amount above the quicksilver, it will not tap sharp against the upper end of the tube when the barometer is quickly inclined from a vertical position, so as to make the mercury rise above its level, nearly to the top, and then gently jerked lengthwise and backwards. If the blow is puffy and dead, or is not heard at all, the amount of air must be considerable, and may be expelled by inversion.

In fixing the barometer, choose a good light near a window, but not exposed to sunshine, in a retired apartment, little liable to sudden changes of temperature or to drafts of wind: adjust the tube to a vertical position by a plumb-line, and fix it so as never to shift from that position. Before reading off, give a few taps on the instrument, enough to make the upper end of the column of quicksilver shake visibly, as the mercury is apt to adhere to the glass, and give erroneous readings. In reading, bring the index always opposite to one part. The correct part to choose is the summit of the convexity of the mercury, to which the index should be made a tangent; but if this be difficult to hit, either from the construction of the index or the want of a proper fall of light, the line of junction of the mercury and glass may be taken: in that case the tapping should never be omitted. Whichever mode of reading is once adopted should be stated, and always adhered to. A piece of white paper placed behind the upper part of the tube will generally enable any one to read off by the convexity of the quicksilver. In placing the index, notice whether it appears to shift a little up and down, as the eye is raised or depressed. This is called parallax, and is a source of uncertainty, to be avoided by placing the eye in reading always on the exact level of the top of the mercurial column.

Barometric observations require corrections of three kinds; and to render them available and comparable with others, it is necessary that their amount should be ascertained and distinctly stated. The first is called the zero correction. It includes several subordinate corrections arising from different sources, such as that originating in the faulty placing of the scale of inches, that due to the capillary depression of the mercury in the glass tube, and the constant part (which at a fixed station is nearly the whole) of the depression arising from the presence of air or vapour in the upper part of the tube.

To determine the zero correction, the barometer must be compared with a standard instrument; such as that at the Royal Observatory for instance, or some other which has been compared with it, or with some standard of equal authority. Such comparison ought never to be omitted before forwarding the barometer to its place of destination, nor should any opportunity be neglected of comparing it, when fixed in its place, with a good portable barometer. In making such comparisons, all that is necessary is to record the readings of both the instruments, after at least an hour's quiet exposure, side by side, that they may have the same temperature. If compared by two observers, each should read off his own barometer in his usual manner, and each should take a mean of several readings, then each should verify the other's results; by this means the zero of one standard may be transported over all the world, and that of others compared with it ascertained.

The amount of the zero correction is often very large, as two or three-tenths of an inch; but its influence on the mean results of recorded observations falls wholly on the determination of the heights of the station of observation above the mean level of the sea, and affects little, if at all, any conclusions of a meteorological nature which may be deduced from them: hence, if proper care be taken to preserve a barometer, once set up, immoveable, a long and regular

series of observations with it has a value independent of any knowledge of this element; and it is fortunate that this is the case, as the zero correction is one extremely difficult to determine exactly *à priori*.

In transporting a compared barometer to its place of destination great care is necessary. It should always be carried upright, or considerably inclined and inverted, and over all rough roads should be carried in the hand, to break the shocks to which it would otherwise be exposed. If strapped horizontally under the roof of a colonial waggon, or tied upright against the wood-work, with its head resting on the floor, there is not a chance of its escaping destruction. Strapped obliquely across the shoulder of a horseman, however, it travels securely and well, and with common care in this mode of transport its zero runs no risk of change.

The next correction, and the most important of all, is that due to the temperature of the mercury in the barometer tube at the time of observation. To obtain this, every barometer requires to have attached to, or fixed very near it, a thermometer, called the attached thermometer, which must be read and registered at each observation of the barometer. It is preferable in practice to read off this thermometer first, to avoid the error arising from breathing on, or standing long near it, while reading the barometer itself. The zero of this thermometer should be ascertained by comparison with a standard at the temperature of about 60° Fahrenheit.

The third correction applicable to barometric observations arises from change of level of the mercurial surface in the cistern, owing to the transfer of a portion of its contents to or from the tube. In barometers with small cisterns, and where the lower level cannot be adjusted at each observation, its amount may be large, and its effect being always to make the apparent fluctuation less than the real, in a fixed proportion, it ought if possible to be ascertained. The data necessary to be known are, first, the internal and external diameters of the tube; secondly, that of the cistern containing the mercury, at the surface, where the tube plunges into it. These particulars, as they must be known to the maker, ought to be inquired of him, and indeed ought to be engraved conspicuously on some part of the instrument.

Although all these corrections are necessary for the strict reduction of registered observations previous to registry, it is sufficient to know them. Their effect is in most cases easily and safely applicable to mean results, and to the conclusions therefrom deduced; and a world of troublesome and often mistaken calculations may be saved by so applying them.

Of the External Thermometer.

The external thermometer should have a scale, on which whole degrees are read off, and divisions large enough to admit of estimating tenths, or at least quarters of degrees by the eye. It should be compared with a standard, and the difference stated, at one or more temperatures (the wider asunder the better,) within the range of the climate in which it is to be used. In fixing it, choose a perfectly shaded but otherwise free exposure, and one where no reflected sun-beams from water, buildings, rocks, or dry soil, can reach it, and easily accessible for reading: there fix it firmly and upright. In reading it, avoid touching, breathing on, or in any way warming it by near approach of the person. The quicker the reading is done the better.

Although read off at stated times, notice should be taken of all sudden and remarkable changes of temperature, as indicated by the external thermometer, whenever they occur. In the neighbourhood of the Cape, and in many other parts of the continent, hot winds frequently set in with great suddenness, often in the night, and singular alternations of hot and cold temperature occur, disturbing the regular laws of the diurnal fluctuation; and connected, doubtless, with many interesting meteorological phenomena peculiar to the climate of South Africa.

Of the Maximum and Minimum, or Self-registering Thermometer.

This should be placed horizontally in some place out of doors, shaded from direct radiation and rain, and otherwise freely exposed to air, and so fastened as to allow of one end being detached from the fastening and lifted up, so as to let the indexes within the boxes slide down to the ends of the fluid columns; a more convenient mode, when the steel index is free enough to allow it, than the use of a magnet.

Both the thermometers should be read off as early as possible every morning, and the indexes re-adjusted; but as double maxima frequently, and occasionally double minima, occur in consequence of sudden changes of temperature, it is recommended occasionally to inspect both of them, with a view to ascertain whether the motion of either the mercury or spirit has been reversed in an unusual manner; and such double maxima or minima, when remarkable, should be recorded as "supernumerary," with their dates and leading features.

The self-registering thermometer is extremely apt to get out of order, by the

indexes becoming entangled in the column of fluid. In travelling they should not for a moment be carried with the mercury bulb downwards; if this should happen, they are sure to arrive in a state unfit for use. To correct them is tedious, and always hazards fracture; with great care, however, it may be done as follows:

1st. The Spirit Thermometer.—By many jerks force the index down to the junction of the bulb and tube, then by cautiously heating and cooling alternately the bulb, the tube, or the air vessel at the top, as the case may require, the disunited parts of the spirit may be distilled from place to place, till the whole is collected in one column in union with the spirit in the bulb.

2nd. The Mercurial Thermometer.—When the steel index gets immersed in the mercury, it cannot be moved by a magnet, and lets the mercury pass by its side. First cool the bulb (by evaporation of ether, if necessary) till the mercury is either fairly drawn down below the index, or a separation takes place in the column, leaving the index with mercury above it: endeavour then by tapping, warming the tube, or by the magnet, to loosen the index ever so little; then apply heat to the bulb, and drive up the index, with its superabundant mercury, quite into the air vessel. This requires many trials and much patience. When there hold the instrument bulb downwards, and suspend the index by a magnet at the top, allowing any globule of mercury to drop into the origin of the tube below: then heat the bulb cautiously over a very small clear flame of an oil lamp, till the mercury rises to the very top of the tube, and fairly unites with the globule there awaiting it. Let the bulb cool, and the mercury will sink in one united column; if not, heat it again. When this is accomplished, the index may be set loose, by withdrawing the magnet, and restored to its proper position in the tube.

A self-registering thermometer may be advantageously left (properly secured) for a whole, or parts of a year, on elevated summits or other remarkable points, to ascertain their maxima and minima of temperature during absence. In such cases take care to defend them from discovery, or accident from wild animals, birds, snakes, &c. In taking it up for reading off, observe not to derange the indexes, and do not leave it without seeing that the indexes are in contact, and the temperature that of the air at the moment.

Of Thermometers Buried in the Earth.

Thermometers buried at different depths, for the purpose of examining the monthly changes of temperature of the soil, should have their balls and lower

part of the scale well wrapped up in woollen cloth or pounded charcoal, and should be placed in strong earthen vessels, which may be entirely withdrawn from the ground, so as to allow of inspecting and reading off the scale without exposing the balls to any possibility of changing their temperatures while under examination. The vessels should be fitted with covers, to defend the scale from injury in burying and digging up.

A pipe of earthenware (composed of separate pieces,) or one of wood, may be sunk 10 or 15 feet below the surface, into dry earth, and a thermometer, defended as above, lowered *by a chain;* the pipe being then obstructed at every 2 feet by some stuffing readily hooked up, the thermometer may be easily examined, and a register of its indications kept with very little trouble. In like manner the temperature of wells may be registered.

Of the Temperature of the Sea.

The surface temperature of the water at sea should be registered, as a matter of course, with the same regularity and at the same hours as the barometer and thermometer. It is more conveniently (and with quite accuracy enough for the purpose) obtained by taking up a bucket full of the water, and stirring round the thermometer in it. Whenever ■ change to the extent of 2° Fahrenheit appears to have taken place since the last observation, a fresh bucket full should be taken up, and the observation repeated. It should also be noticed whether rain has fallen since the last observation. A sudden depression of 3° or 4° indicates the near approach of land. In a voyage from England, lately made by a member of this committee, the temperature of the surface water fell at once 9° Fahrenheit on approaching within a few miles of the entrance of Table Bay.

The temperature of the sea at considerable depths can hardly be regarded as a subject of ordinary meteorological inquiry and regular registry, though undoubtedly one of much physical interest, for which reason it is not considered necessary to dwell further on it.

Of the Hygrometer, &c.

In the absence of Daniell's hygrometer, or of ether to cool it, the degree of dryness of the air may be ascertained by observing the temperatures marked by

two thermometers, suspended freely side by side (but not in contact), in the shade, and completely defended from all radiation *to* or *from* the *sky;* the one having its bulb and stem naked, the other with the bulb and lower part of the stem wrapped in linen or cotton, and thoroughly wetted with pure spring or rain water. The temperatures indicated by both should be noted when the wetted thermometer refuses to sink lower, and the conclusions left for subsequent calculations. The naked thermometer may be the "external thermometer" itself, in which case a coated thermometer may be kept always suspended near it, completely screened as above mentioned, and wetted some minutes previous to the regular daily readings.

If a hair hygrometer be used, its points of absolute moisture and dryness should be frequently ascertained, as they are apt to change. The former may be found by keeping it some time in a close covered jar lined with wet blotting paper, and having water in it, and noting the point of moisture beyond which it refused to go; the latter, by keeping it in the same manner in a jar perfectly air tight, over fresh burnt quick lime, till it refuses to indicate a higher degree of dryness.

The best measure of the *momentary evaporating power* of the air seems to be the depression of the wetted thermometer below the dry one: but the *actual evaporation* from a given surface is quite another thing; and a question may very reasonably be raised, how far any useful approximation to a knowledge of the total evaporation from an extensive and diversified surface, unequally moistened, and variously exposed to the sun, defended by clouds or refreshed by dews, *can* be obtained by any small or local experiments.

The rain gauge is an instrument of such extremely easy construction, that any person who lives near a tinman can procure one. In a climate so arid as that of Africa, however, it must be remembered that it will often need examination and cleansing, owing to long intervals of disuse, in which insects and dust may lodge: it will often happen, too, that the slight rain of one day, if left unregistered, will be entirely lost by evaporation in the next; nay, that slight and transient showers may never enter it, being evaporated from it as they fall. The effect of copious dew, too, must be separated from that of rain; so that the mere registry of the contents of the gauge is not of itself a sufficient indication whether rain has fallen in the night or not: however, there are usually good reasons for decision on this point from other indications.

Attention to the amount of dew is very necessary, not only because the meteorological questions involved are of a high degree of interest generally, but because in arid climates the dews are almost of as much importance to the maintenance of vegetation as the rain.

In stating the quantity of rain daily received in the gauge, the height of the receiver above the soil should be mentioned, experience having shown that the quantities of rain which actually fall on a given area on the ground, and at a very moderate height above it, often differ materially. In some localities and circumstances, the rain-drops receive accession from the air as they descend, in others they undergo partial evaporation. The former is generally the case in cool moist climates, the latter may be expected in this country.

Of the Wind.

The points most important to remark respecting the wind, are—

1st. Its average intensity and general direction during the several portions of the day devoted to observation and registry.

2ndly. The hours of the day or night when it commences to blow from a calm, or subsides into one from a breeze.

3rdly. The hours at which any remarkable changes of its direction take place.

4thly. The course which it takes in veering, and the quarter in which it ultimately settles.

5thly. The usual course of *periodical winds*, or such as remarkably prevail during certain seasons, with the law of their diurnal progress both as to direction and intensity; at what hours and by what degrees they commence, attain their maximum and subside, and through what points of the compass they run in so doing.

6thly. The existence of crossing currents at different heights in the atmosphere, as indicated by the course of the clouds in different strata. In observing these, it is advisable to fix the eye by some immoveable object, as some point of a tree or building, the sun or the moon, otherwise mistakes are apt to arise.

7thly. The times of setting in of remarkably hot or cold winds, the quarters from which they come, and their courses, as connected with the progressive changes in their temperature.

8thly. The connexion of rainy, cloudy, or fair weather, with the quarter from which the wind blows or has blown for some time previous.

9thly. The usual character of the winds as to moisture or dryness, not as deduced from mere opinion or vague estimation, but from actual observation of the hygrometic state of the atmosphere during their prevalence.

Among these particulars, it will be seen that some are of a nature susceptible of daily observation and registry, while others call for an exercise of the combining and inductive faculty on the observer's part, and cannot be made out otherwise than by continued attention and habitual notice of phenomena, with a view to the investigation of their laws. The general impression left upon the mind as to any of the points of this kind above enumerated, by the occurrences of the past month, will therefore be more properly stated in the way of summary remarks at the end of the Monthly Registers, than as entries under particular days.

Of the State of the Sky.

In describing the state of the sky as to clouds, &c., the observer will bear in mind that it is only in that region of the sky which is vertically above him that the true forms and outlines of the clouds are exhibited, and the area they cover as well as the intervals between them distinctly seen. As they approach the horizon in any direction, their extent is fore-shortened by perspective, their apparent magnitude diminished by distance, and their intervals covered in and hidden by their mutual interposition. In estimating therefore the quantity of clouds in the sky, regard must be had to this; and our judgment should rather be formed on a view of the region extending from the zenith every way half-way down to the horizon, than from the aspect of the heavens below that limit. It would be better to notice both, and state separately the proportions in which each are covered, and the quarter of the horizon towards which the chief masses in the lower region lie.

The general aspect of clouds, as classed under the heads cumulus, cirrus, stratus, &c. should be noticed, and especially the height of their inferior surfaces, or the level of the *vapour plane*, should be estimated. In a mountainous region this is easy, so long as the vapour plane is below or not far above the summits of the hills; and in such regions the formation and dissipation of cloud in the neighbourhood of the mountain summits, under the

influence of certain winds, form a subject of study of a highly curious and interesting nature.

The formation of clouds at night, during calm weather, under the influence of a gradually descending temperature, is another point worthy of attention. It frequently happens, that without any perceptible wind, the sky will suddenly become hazy in some one point, and the haze condensing and spreading in all directions, without a wind, the whole heaven will become overcast in a remarkably short time. The same thing will sometimes occur nearly at the same hour for many nights in succession. Such phenomena should be noted whenever they occur.

Two or even three strata of clouds are very common in this district of South Africa; the lowest frequently resting immediately on the land or sea. The height and thickness of these strata, their connexion with cross or opposite currents of wind in the regions where they subsist, and the laws of their formation and gradual intermixture, deserve to be studied with care, and with reference to the hygrometic state of the air at the time and place, and for several hours before and after.

Of Thunder and Lightning, and of the Electric State of the Air.

Connected with this part of the subject is the observation of shooting stars and luminous meteors. Remarkable ones should be noticed, and the moment of their appearance, their direction, duration, length of path, and *course among the stars*, ascertained and noted, with the phenomena of their increase and decay of light, apparent size, separation into parts, trains left behind, &c. The *general* direction (if any) which they observe on particular nights, is a point also to be attended to. Such are the frequency and brilliancy of these splendid phenomena in the clear sky of this colony, that there can be no doubt of their affording an available method of ascertaining the differences of longitude of the most distant stations, if duly observed by persons furnished with means of ascertaining the time.

Thunder-storms, of course, will be noticed when they occur under the general head of the weather; but it is of consequence also to notice distant lightning, not accompanied with thunder audible at the place of observation (by reason of

its great distance,*) especially if it takes place many days in succession, and to note the quarter of the horizon where it appears, and the extent it embraces. In an actual thunder-storm, especial notice should be taken of the quantity of rain that falls, and of the fits or intermittances of its fall, as corresponding, or not, to great bursts of lightning, as also of the direction of the wind, and the apparent progress of the storm with or against it.

Observations of the electrical state of the air in serene weather are unfortunately too much neglected. The apparatus they require is simple, and by no means costly, and may be constructed indeed by any one for himself with ease.

If the committee in this their first Report do not dilate on this, and other of the less usually practised observations of meteorology, it is because they wish for the present chiefly to call attention to the accumulation of regular and daily observations of a more definite and numerical character. With this view they have drawn up, and by the liberal aid of Government, have procured to be printed skeleton forms, of which a copy is annexed, for immediate distribution among such correspondents of the institution, and others, as may be willing to undertake their filling up. These comprise, it is true, only the registers of the barometer and its attached thermometer, with that of the external thermometer, and a column of remark for wind and weather, as being the most essential and indispensable elements of meteorology; but it is in the power of any one who pleases to supply additional information, and to those who have leisure, instruments, and inclination for the task, the committee would particularly recommend the regular observation of the wet thermometer, those of the self-registering thermometer, and weekly or monthly observations of thermometers buried at different and progressive depths beneath the surface of the soil.

The printed forms provide for the arithmetical convenience of casting up the *means* for each month. In doing so it is requested, that care will be taken to verify the result by repetition; and (that usual sources of error may not escape notice) they recommend in every instance, before adding up the columns, to look down each, to see that no obvious error of entry (as of an inch in the barometer, a very common error, or what is more difficult of detection, an error

* Thunder can scarcely ever be heard more than twenty or thirty miles from the flash which produces it. Lightning, on the other hand, may be seen (or at least its reflection on the clouds, forming what is called sheet lightning,) at the distance of one hundred and fifty or two hundred miles.

in the first decimal place,) shall remain to vitiate the mean result. It is, perhaps, unnecessary to more than mention the precaution of *counting* the days in *each* column on which observations occur, so as to admit of no mistake in the *divisor*, and to use throughout the decimal arithmetic in calculating the mean results. Care and exactness in these points will in most cases add greatly to the value of the communications, as it will be quite impracticable for the committee, should observations flow in masses, unreduced or erroneously reduced, to undertake the overwhelming task of recomputing them.

Although not, strictly speaking, a branch of meteorology, yet as the collection of observations of the tides has been made a part of the duties of your committee, they propose the following stations as points where it would be especially desirable to obtain regular observations of the time and height of high and low water, according to the rules and on the plan proposed by Mr. Whewell, in his late researches on this subject; and they earnestly invite communications on this head from any residents at those parts who may have leisure, and take interest enough in the important questions connected with the subject.

Cape Town	Port Elizabeth
Simon's Bay	Knysna
Saldanha Bay	Tristan D'Acunha
Ascension	Madagascar
Mauritius	Mozambique

In Cape Town and Simon's Bay, they have the pleasure to report, that a series of observations, under the superintendence of Captain Bance and Mr. Levien, have already been undertaken at the instance of the Astronomer Royal, and are now in active progress.

Table showing the Maximum and Minimum of every Month for the Year, from 1822 to 1834, inclusive, in Lower Canada.

Months.		1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	Mean.	Mean Dif.
Jan.	Max.	42	40	44	38	36	36	42	40	32	43	50	43	43	41	62
	Min.	—24	—20	—17	—12	—10	—25	—27	—26	—18	—24	—21	—31	—21	—21	
Feb.	Max.	47	44	50	46	46	42	44	25	51	42	34	45	47	43	63
	Min.	—16	—18	—31	—20	—26	—28	—12	—12	—24	—21	—29	—16	— 9	—20	
March	Max.	15	46	48	52	42	42	52	50	70	52	50	52	54	51	54
	Min.	1	—17	2	4	8	— 1	— 6	— 1	— 1	— 1	—12	—12	0	— 3	
April	Max.	56	58	53	58	57	62	60	60	82	56	49	62	82	61	47
	Min.	9	6	11	11	5	24	10	27	29	10	— 1	18	20	14	
May	Max.	74	76	72	74	84	84	76	88	91	84	74	86	80	80	44
	Min.	36	33	33	42	36	36	38	38	35	45	24	33	35	36	
June	Max.	80	84	84	96	90	88	94	86	86	92	85	89	93	88	43
	Min.	50	42	46	50	50	44	50	48	41	44	40	33	45	45	
July	Max.	90	92	92	94	95	95	84	88	101	95	97	91	97	91	40
	Min.	52	52	48	48	56	52	52	43	61	45	50	48	60	51	
Aug.	Max.	88	84	86	91	91	90	88	85	89	90	86	89	88	88	39
	Min.	49	48	50	50	52	48	54	50	57	49	40	41	51	49	
Sept.	Max.	79	76	80	81	74	76	74	76	74	80	73	75	85	77	39
	Min.	38	45	36	34	40	49	48	32	38	32	37	37	30	38	
Oct.	Max.	68	70	66	74	71	61	64	69	61	76	65	65	62	67	42
	Min.	28	25	23	28	26	25	26	26	26	28	22	25	22	25	
Nov.	Max.	48	46	48	60	42	44	46	50	58	50	54	46	51	50	37
	Min.	16	2	14	10	14	8	15	8	20	20	17	11	8	13	
Dec.	Max.	40	42	44	40	44	35	38	44	57	43	25	43	48	42	53
	Min.	—23	—13	—21	—25	5	7	—19	— 7	— 9	2	— 8	— 3	—24	—11	

Note.—This Table was arranged by Major Stack, 24th regiment, while quartered in Lower Canada from 1829 to the end of 1834, by setting down the hottest day and the coldest night in each month for the above period. The Table previous to the commencement of his diary was taken from a Meteorological Diary, published by a scientific gentleman in Quebec.

Rutherford's self-registering day and night thermometer was found the best to go by. Six's thermometer was not to be depended upon in extreme cold. It is very desirable that officers should follow the example set them by Major Stack, and avail themselves of the many opportunities they have of collecting valuable information upon meteorological subjects. The instruments required are cheap and portable; and nothing is necessary but a little attention in making the observations, and a proper system of registering them.

XVIII.—*On the Construction of Barracks for Tropical Climates.* *By Captain* Smyth, *Royal Engineers.*

The causes which have influenced the great mortality amongst our troops in tropical climates, having lately attracted the particular attention of the military authorities; and as many discordant opinions have been given, from a limited and partial view being taken on this subject, I think it may not be without advantage, and that it is not inconsistent with the objects of the professional memoir, to state the opinions to which I was led thereon, during a residence of nearly six years in the West Indies; when, from the nature of my professional duties, my attention was particularly directed to the consideration of the subject.

That a proper system of diet, of exercise, and employment (which are generally too much neglected,) clothing adapted to the climate for day and night, avoiding intemperance, unnecessary exposure to night air (particularly during the unhealthy season,) and a more frequent and regular relief from climates where the risk of life is so great, all form elements in the consideration of this subject I readily admit; but experience and observation convince me, that, with a comparative neglect of these, the health of the troops may be greatly preserved by the adoption of a system of building for barracks, or cantonments, adapted to, and varying with the localities in which they may be situated.

The soldier in warm climates passes a large portion of his time in his barracks; and the proper construction of them, with a view to his health and comfort, is therefore a matter of great importance. The attention of the Corps has been much called of late years to the architectural requirements of convenience, strength, and durability; but I do not think that sufficient attention has been given to vary the construction according to the varying circumstances of climate and situation, and a general and uniform system has been too much followed, not adapted to the many cases to which it has been applied.

The remarks I now venture to offer, in the hope that they may bring the subject under the consideration of my brother officers, have reference particularly to tropical climates, and to climates where marsh miasma is prevalent.

It is desirable to have buildings intended as barracks for soldiers in tropical climates, so spacious as to give at least from 300 to 500 feet of cubical content

interior space for each man, and for hospitals, from 800 to 1000 for each patient for which they may be constructed; to preserve the buildings as much as possible at a uniform temperature; to keep them as dry as possible; to preserve a perfect command of ventilation, and to be enabled to exclude entirely the night air.

The choice of locality, a point that most materially influences health, is seldom altogether in the power of the Engineer Officer, but is fixed by military or commercial views; and from the operation of these causes, he is constantly called on to build barracks and hospitals in situations the most unfavourable to the preservation of health; even in such climates, as to leeward of a marsh, or at that elevation above it which experience has proved to be the most injurious to life: and it is peculiarly with a view to such situations that I would call attention.

The usual construction for a barrack in the West Indies is a building of wood or stone, with an open gallery either partially or entirely round it, and having shutters of wood or jalousies (fixed or moveable louver boards) to close the window openings in the walls. The interior space has been usually much too confined, giving only from 150 to 300 cubic feet per man, and during the late war not half this content. Where the galleries do not extend on the sides and gables of the building, it is of course greatly exposed to the effects of the sun and rain; and the roofs, which were till lately covered with shingles, in most cases only on laths, afforded little protection from the sun's rays by day, and were liable to very sudden changes of temperature by night.* The buildings are usually placed so that the front and one gable may receive the prevailing sea breeze, and are left as much as possible open to its effects. This in itself is a great evil, as soldiers are in general very thoughtless, and when returning from exercise heated, throw off their clothes, and are left exposed to violent currents of air, which produce sudden chills, and bring on fever, dysentery, and rheumatism;† and it

* The old barracks had seldom more than a gallery to windward. Those built since Sir C. Smith commanded in the West Indies have had galleries to surround them, jalousied to leeward; and in the hospitals, I believe, jalousies in all the galleries.

† This is one reason why so many officers prefer exercising the troops in the morning, before the sun is high and the sea breeze sets in, thus exposing the men to the heavy dews, and the annoyance of musquitos and other insects, which in some of the colonies are insufferable at such times; when later in the day, the men would suffer less either in health or comfort, the oblique rays of the sun in the morning being very oppressive. In a wing of a regiment that served in Guiana with me, the officer commanding directed that the non-commissioned officers should see the soldiers change their flannel shirts on coming in from exercise, and the results were very beneficial. The hospitals were free from sick; and I think only four men died from the wing in one year, though the men were employed working morning and evening in the formation of a parade ground within the barrack square, contrary to the practice of other regiments. Much attention was given, in the regiment I allude to, to the diet of the men; vegetables and pepper were largely used in their soups; hot coffee was supplied at gun-fire in the morning; and though many old soldiers in the regiment were addicted to intemperance, the evil effects were not so manifest as in other corps in the country, who neglected these precautions, and kept the men in idleness.

is also attended with this additional evil, that when the land wind prevails the buildings are equally exposed to the influence of the deleterious miasmata, with which every breath of air is charged, and which are permitted to circulate through the rooms, in many cases by night as well as by day.

The principles upon which I conceive a barrack should be constructed, in situations exposed to the influence above mentioned, are these:—The interior space should be as large as possible, with due regard to economy; the outer walls should be inclosed as in temperate climates, and the openings for windows, on the sides and gables exposed to the marsh miasma, closed by glazed sashes, and on the sides and ends opened to the sea, by moveable jalousies, and in *very unfavourable situations* closed in the same way as the other sides and ends. A gallery of 10 or 11 feet wide should be left between the outer wall and the main wall of the building; the latter should be opened at the floor (to be closed, when requisite, by ventilating shutters a foot wide,) and the main wall carried up to the height of 7 or 8 feet; openings or doorways from the gallery to the room being made in some of the spaces left between the bedsteads: the space between the main wall and floor above, or ceiling, to be left open. The roofs should always be boarded, covered with slates, and have louvered ventilators at the ridge. Pediment roofs are best, as jalousies may be placed in them, and a thorough ventilation obtained. The partitions should be as few as possible; but if it be desired to have small rooms, the divisions should be made by moveable jalousies, and sliding doors in them, carried to the same height as the side walls.

In hospitals in the damp islands of the West Indies, and in Guiana, wire gauze should be fixed in frames in the window-openings.*

* At the suggestion of Captain Brandreth, Royal Engineers, iron wire blinds were ordered to be tried in the new hospital at Demerara, and were demanded from England, but they were not supplied during the period I was in the colony. When referred to by Captain Brandreth on this subject, I fully concurred in the opinions he expressed, having for many years in my own quarters in Canada (at Isle aux Noix,) and in Demerara, used frames of wood, with leno or musquito net stretched on them in the opening both for windows and doors, not only with a view to exclude insects, but also to exclude the miasmata. In several hospitals in Italy fine wire gauze has been

In the exposed situation of many of the West India barracks to the pestilential effluvia from the adjacent swamps, and when the wind from the land blows over them, it is a matter of vital importance to be enabled to close the side and end

placed in the windows instead of glass, and it has proved efficacious in arresting the miasmatic current. I would not, however, where it is desirable to exclude the night air, trust to the gauze wire alone: if glass be not used with it, I would have shutters to close at night. In the 'United Service Journal' for July 1837, there is a copy of a letter from Dr. Trail, Professor of Medical Jurisprudence at Glasgow, to a General Officer (whose opinion on the modes of preserving health in tropical climates had been requested from the Horse Guards,) in reply to some queries he had put to him, in which he recommended the use of copper wire gauze (such as is employed for safety-lamps) in buildings intended for hospitals, and the use of gauze curtains to the beds as an additional security.

The huts formerly built for the negroes in Guiana, of hardwood, and thatched or covered with the trooly palm, afforded nearly all the advantages for which I seek. They were lofty, with steep roofs, and, from the palm-leaves much overlapping each other, were perfectly dry; were kept at a uniform temperature, cool by day and warm at night: good ventilation was obtained in them, and they were much more spacious than the board and shingled houses now in use. Captain Alderson, Royal Engineers, in No. 19 of first volume, speaks of the value of this material, and I can bear ample testimony to it; but experience will speak more strongly than I can. Since cultivation has so much extended in Guiana, it has become necessary to substitute framed and boarded houses, covered with shingles, for the negroes on the estates; and when the change was made on each estate, the mortality was found greatly to increase. I had occasion to remove some trooly sheds (occupied by the King's negroes in Demerara,) from finding it difficult and expensive to replace or repair them by the same materials; and I experienced much opposition and remonstrance from the occupants before I could eject them, though it was to give them, what *at the time* I thought to be, better houses.

A large trooly shed, occupied by the black and military labourers attached to the quartermaster-general and engineer department, in Demerara, though placed in a very unfavourable situation, was, from the large internal area, freedom from damp, and uniform temperature, much more healthy than the framed and boarded buildings on the old construction, in which, after a shower of rain, the steam and heat were insufferable.

In the old Eveleary barrack in George Town, Demerara, the lower rooms, which were floored on dwarf walls close to the earth, were found very unhealthy, and the water lodged in the space beneath, from want of proper drainage. At the recommendation of Sir C. Smith, the Commanding Royal Engineer in the West Indies, a pavement of Yorkshire stone was laid in the soldiers' barracks, on the surface, which he directed to be sloped from one side of the building to the other, and hatches were left in the floor to throw water down, and to cleanse the pavement. These rooms were then found to be more healthy than the upper rooms, exposed to the land winds; and the same thing was noticed at the colonial barracks at York and Albany, that more men were sent to the hospital from the upper than the lower rooms, though the latter were, from the building being raised on pillars, nearly on a level with the upper rooms at Eveleary. The tables kept by the medical officers afford means of noting such facts as these, and arriving at correct conclusions on such an important subject.

An officer who passed two years in Sierra Leone, informed me that the officers' barracks in that colony have fire-places in each room, built at the recommendation of Dr. Barry, the principal

of the building exposed to it, so as to exclude it altogether, especially during the night. Jalousies do this very imperfectly; and the old plan of shutters is very objectionable, entirely excluding air, and leaving the men exposed to all the inconvenience and evil of breathing the confined atmosphere of a crowded room, or to the alternative of the land winds blowing over their heated bodies.

The jalousied windows on the side not exposed may be partially opened, to obtain ventilation; and as there is a parapet wall between the beds and the window, no evil can result to the men occupying the rooms; but the interior space is so great, on the construction I propose, that if all the ventilators were closed, no evil would result from it.

The suggestions I have offered are not the result of theory alone, as the buildings constructed at Demerara from 1828 to 1833, under my orders, were partially built on the system I here recommend: I say partially, as I had submitted the plans to estimates, and had commenced the buildings before my present opinions were matured, and before I had obtained the sanction of the Commanding Royal Engineer in the West Indies to modify the construction. The result of this partial adoption in the hospitals, and of a more extended adoption of the plan in the soldiers' barracks, has been most satisfactory, and fully justify my recommendation. The average loss of men from the regiments quartered in Demerara in the three years previous to, and the two first of my residence in that colony, was as follows:—1825, 21 per cent; 1826, 18$\frac{1}{3}$; 1827, 25; 1828, 22; and 1829, 17 per cent by deaths; and frequently more than one-half of the numbers in garrison were in hospital, or sick in barracks, from the want of hospital room. The cases of relapse in fever were very common, and always most fatal. When the new buildings were occupied this was of rare occurrence; and during the three last years of my residence the mortality was diminished in the proportion which follows:—1830, 18$\frac{2}{3}$, of which 7 per cent. were black troops; 1831, 13$\frac{2}{3}$, of which 2 per cent. black; 1832, 5$\frac{1}{4}$,

medical officer; and the officers who occupied them were requested to cause a small fire to be lighted in their rooms shortly after sunset, and not to open the rooms again to the night air. This was deemed by many of the occupants of the barrack to be such an absurdity, that they would not comply with the request, and they lost their lives. My informant was wiser, and adopted Dr. Barry's advice, having a fire lighted as he went to mess, allowing it to expire before his return. Though exposed to the night air in returning to his room from the mess-room, he never enjoyed better health in Europe than in that climate. The use of stoves in the storehouses in the damp colonies, would be found most beneficial to the interests of the service, in the preservation of stores from the effects of damp and vermin.

of which $1\frac{1}{4}$ per cent. black. This statement, which I obtained from the principal medical officer, will show at once the operation of some favourable causes on the health of the troops; and I believe no one will dispute that those I have stated were these causes. The statement of deaths, including the colonial barracks on the old construction, do not show all the advantages that resulted from the occupation of the new buildings; but I have not now the means of ascertaining the relative numbers who died from these and from the new barracks.

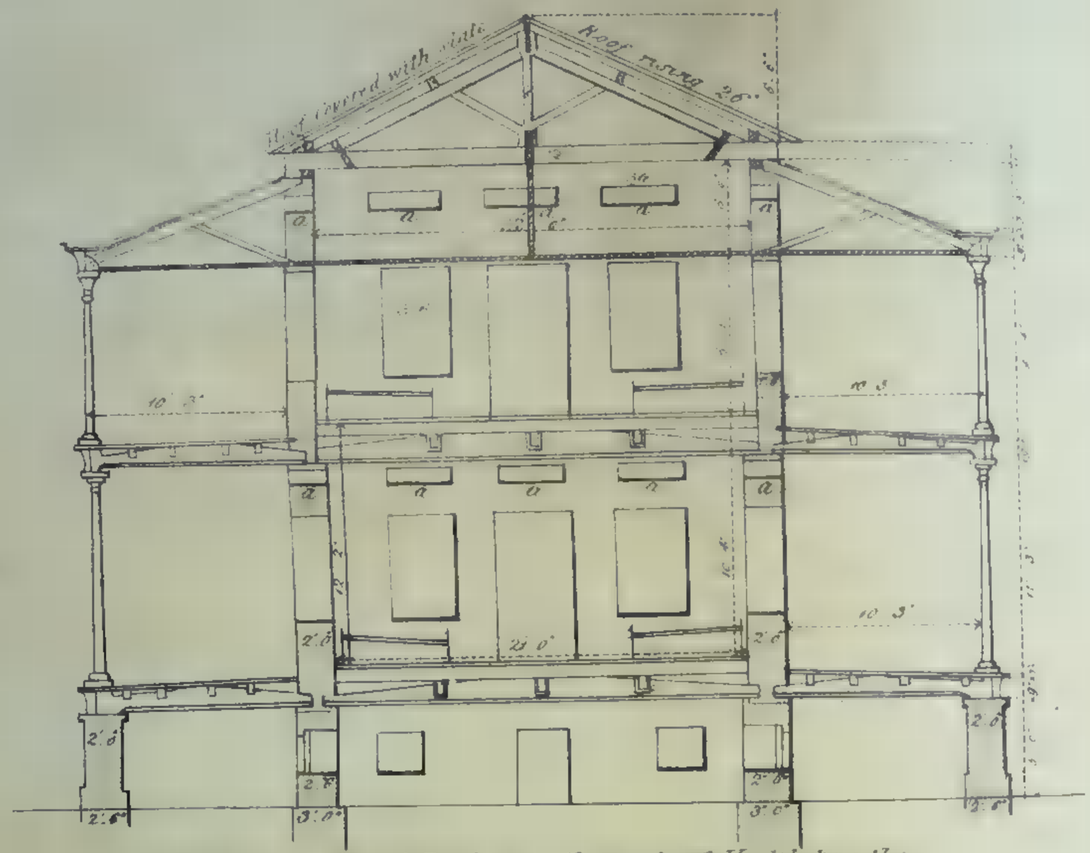
With respect to the mode of building which I recommend, I am of opinion, that it would be less liable to injury from hurricanes * than the buildings on the plan hitherto followed. The Ordnance hospital at Barbadoes, on Sir C. Smith's plan, was the only building on a plan similar, in some respects, to those I propose, that I had the opportunity of seeing after the hurricane of 1831, and this suffered comparatively little. The barracks at St. Lucia, and the hospital at Antigua, have experienced two hurricanes since they were built, as well as that at Barbadoes, and may form a fair data on which to ground an opinion as to this point. I observed also in Bridge Town, that the framed wooden buildings suffered much less than the stone with galleries. In situations exposed to hurricanes it would be desirable to have shutters to the windows: I would, however, offer any opinion on this part of the subject with diffidence, as I have not the same advantage of personal observation and examination of the effect of hurricanes as the officers in the northern islands had; but it appears manifest, that the more perfect union of parts in a well framed building, in which the action of the wind is excluded from the interior, would render it less liable to injury than buildings where this union is less perfect, which is ordinarily the case in a combination of wood and stone, or brick; and the great advantage of Sir C. Smith's iron frames, consists in their obtaining a more perfect system of tie through the stone-work and connexion of the parts with each other, than can be obtained, without considerable labour and expense, for roofs and galleries framed in wood.

JOHN SMYTH,

Captain, Royal Engineers.

* The hurricanes seldom extend nearer to the equator in the northern tropic than the 10th degree, so that Trinidad and Guiana are free from this evil.

Fig. 3.



Section thro' the line A B. shewing the mode of Ventilating the Rooms a a a a. Apertures to receive the Ventilators.

Scale 10 Feet to One Inch.

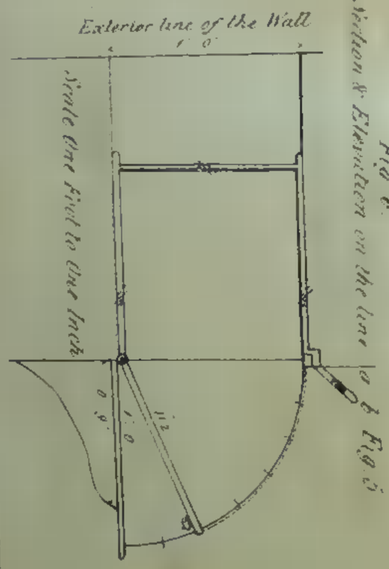


Fig 6. Section & Elevation on the line a b Fig 5

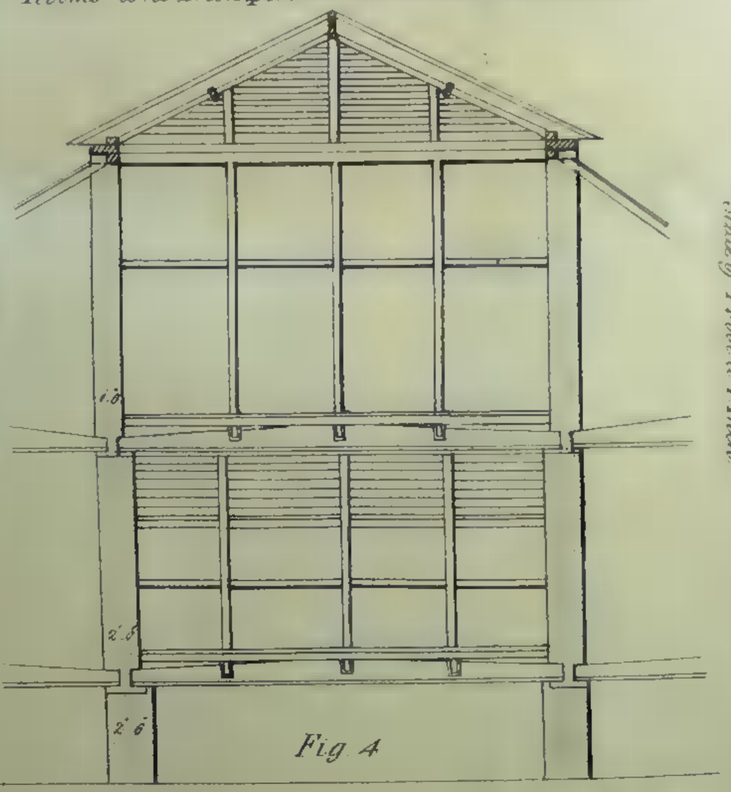
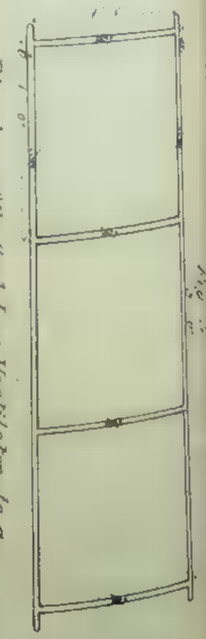


Fig 4



Elevation of the Cast Iron Ventilator, to a Scale of 1 Foot to 1 Inch.

Section and Elevation of the line C D. Fig 2. shewing the Jealousies and Partitions of the Rooms.

Scale 10 Feet to One Inch.

XIX.—*Memorandum relative to a System of Barracks for the West Indies, recommended by Colonel Sir C. F. Smith, C. B., R. E., and approved by the Master-General and Board of Ordnance. By Captain* Brandreth, *Royal Engineers.*

In 1824 Sir Charles Smith submitted a proposition to the Board of Ordnance for a new system of barracks that should, as far as was practicable, insure uniformity of design. Having maturely considered the circumstances of climate, and local peculiarities, he recommended that the barracks should be divided into two classes; the distinction between each class to consist mainly in the breadth of the building, which was to be regulated by the proposed site.

1st Class. The buildings of this class consist of a basement, one or two floors, and a gallery surrounding each floor; the average breadth of the building in the clear is twenty-one feet; the walls and piers are of brick or stone; and the girders, joists, columns, and cornices, or ranging plates, of cast iron. The bridging-joists and floors of the main building are of wood, and the pavement of the galleries of York flags. The roof is of hardwood; the doors and jalousies are of cast iron; the length of the floor is divided into rooms to accommodate eighteen or twenty men in each; and the partitions are formed in the upper part with jalousies to insure the circulation of air.

The following description, and the annexed plates, will show the various details of the building.

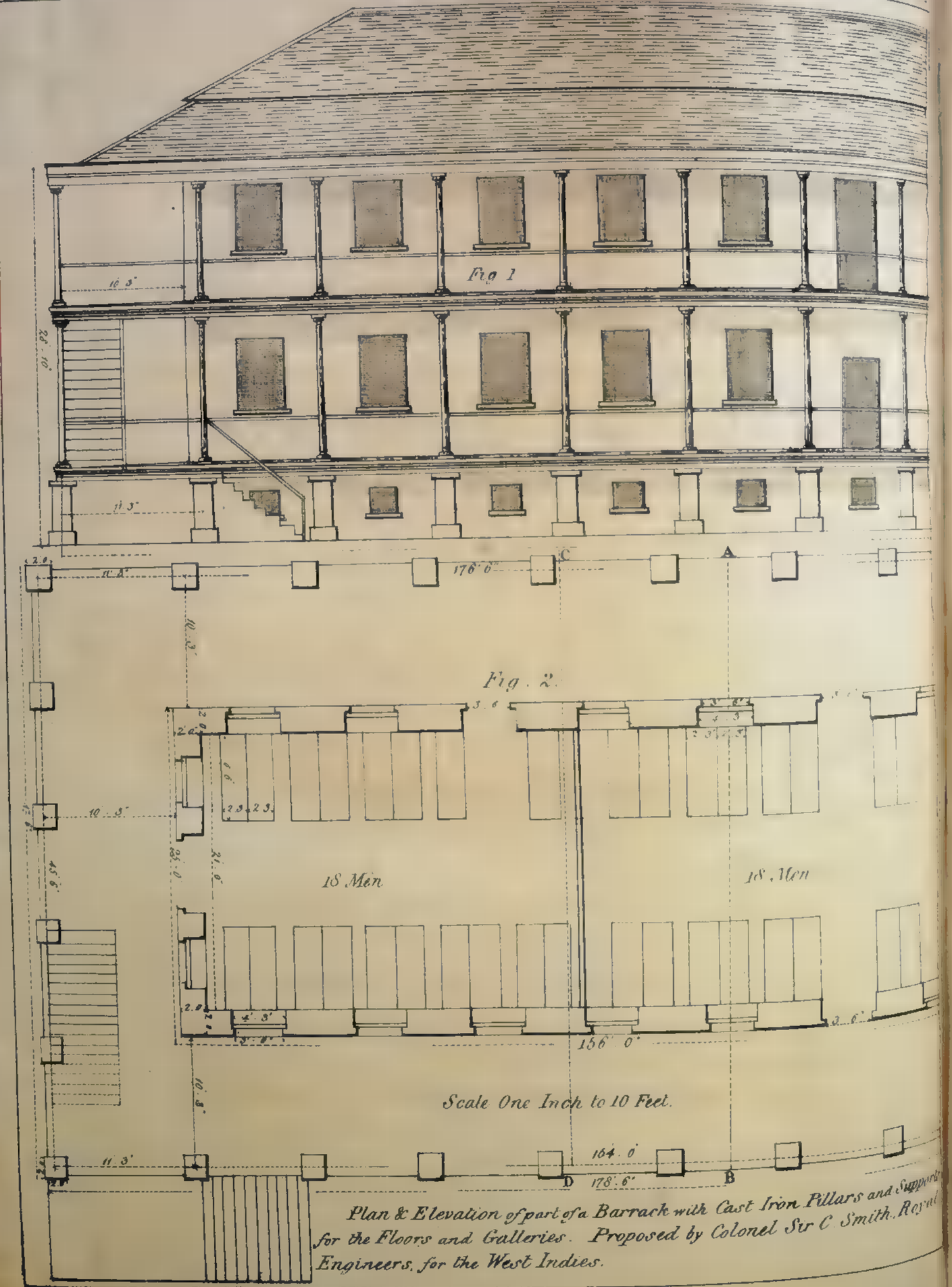
Plate 1, *figs.* 1 and 2, show the general plan and elevation of a portion of a barrack for 200 men with two floors.

Plate 2, *fig.* 3. Section through A. B. *fig.* 2, showing the general application of iron, the transverse ties obtained by the girders, main shoes, and tie bars, and the general construction of the roof.

Fig. 4. Section through C. D. *fig.* 2, showing the jalousies and partitions of the rooms.

Figs. 5 and 6 show the cast iron ventilators, and the mode in which they are fixed in the walls in the positions marked in *fig.* 3.

Plate 3. Plan of the floor of the main building and galleries, showing the



mode in which the girders and joists are laid, the bridging joists of hardwood in the main building, the superstructure of York flags in the galleries; the shoes on which the girders rest, the iron plates through which the outer ends of the lower girders are passed, and the position of the staircases.

Plate 4. Plans, sections, and elevations of part of the iron work, showing the girders and joists of the main building and galleries, and the shoes and square plates on which the girders rest.

Figs. 1, 2, 3, and 4. Plan, elevation, and sections of the girder of the main building.

This girder is calculated either for a ground or upper floor, each length of nine feet in the building will require one main girder.

Figs. 5, 6, 7, and 8. Plan, elevation, and sections of the gallery girder.

This girder is for a ground or upper floor, one end rests on an iron shoe in the wall, and the other end (if on the ground floor) rests on a stone pier with an iron plate between the girder and pier; if applied to an upper story, the end of the girder passes through the cap of the lower and base of the upper column: for each length of building of nine feet (front and rear), two gallery girders are required.

Figs. 9 and 10 Elevation and plan of the short angle girder.

Two of these are required for each end of a gallery, one of which has the bevel flanch reversed. This girder is calculated for a ground or upper floor: the bevel is dovetailed into the long angle girder.

Figs. 11, 12, and 13. Elevation plan and section of the long angle girder.

Two of these are required for each end of a gallery, either for upper or lower floor.

Fig. 14. Plan of a square iron plate for the head of the lower gallery girder to rest upon.

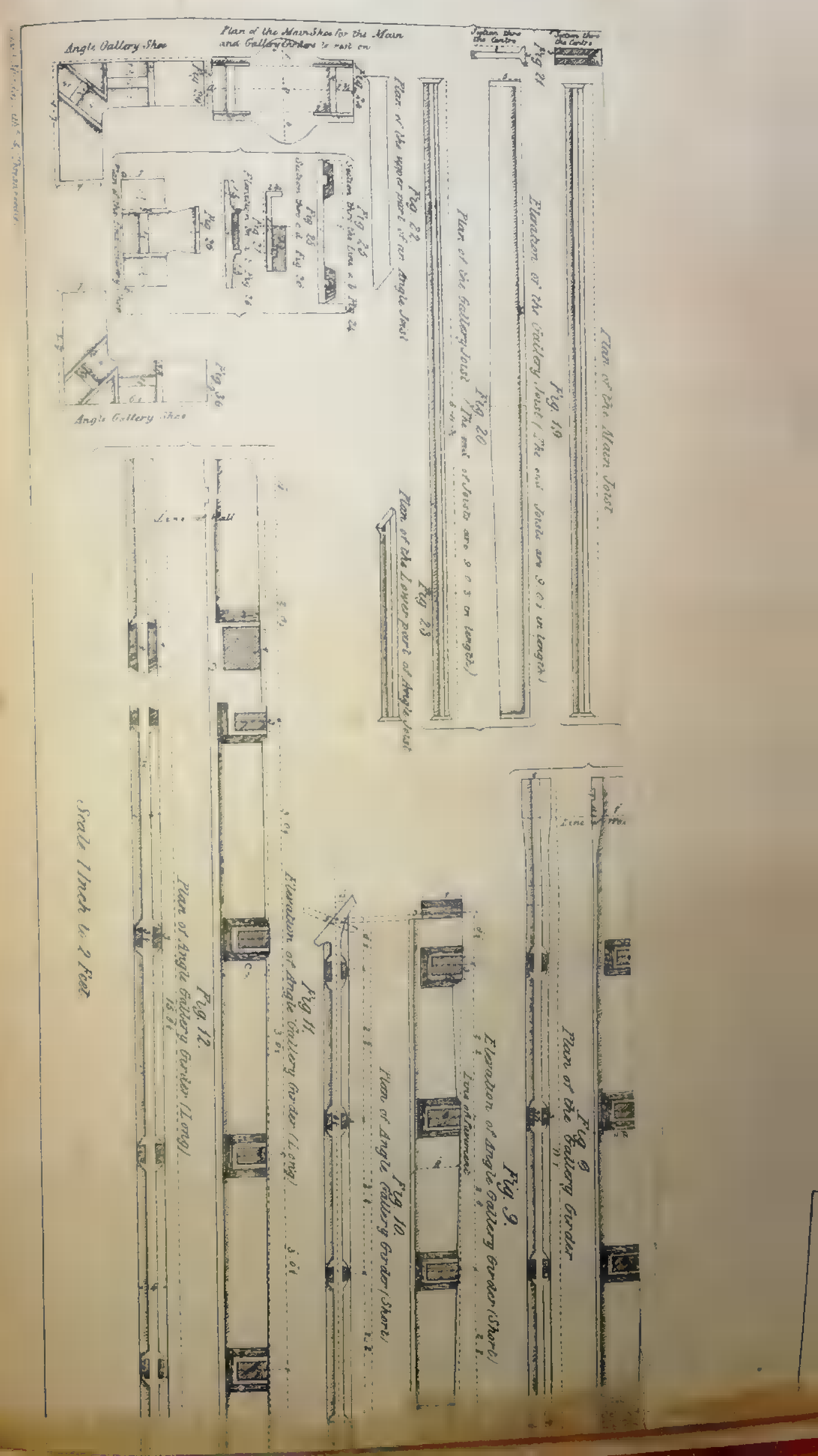
One of these plates is required for each lower girder, to prevent the outer end of the girder from crushing the stone pier on which the plate will rest.

Figs. 15, 16, 17, and 18. Elevation, plan, and section of the binding joist for the main building.

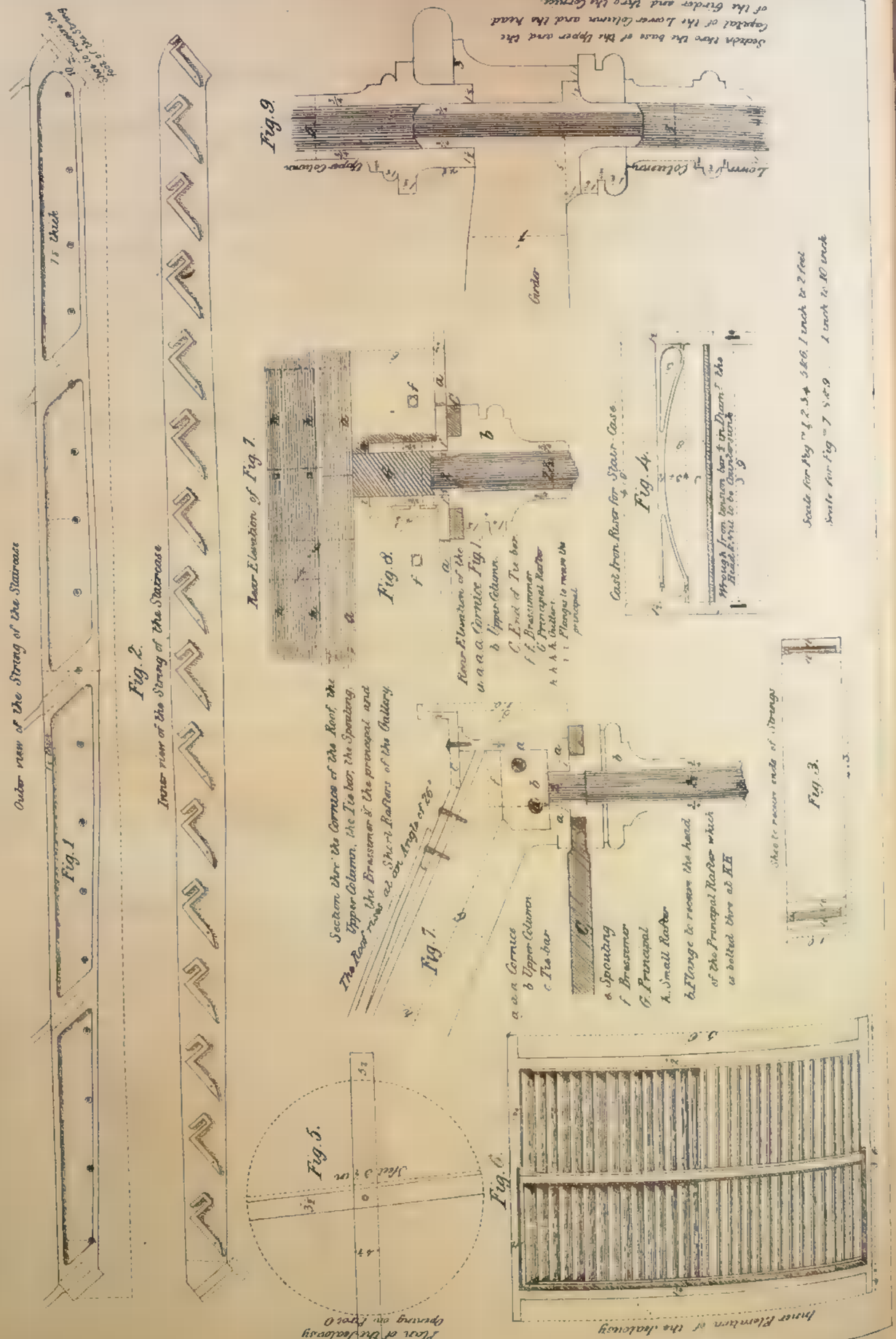
This joist is calculated for either an upper or lower floor, and each length of nine feet will require three main joists.

Figs. 19, 20, and 21. Plan, elevation, and section of a gallery joist.

This joist is calculated for an upper or lower floor, and each length of building (front and rear) will require eight joists. The end joists are the same as



Plans, Elevations and Sections of part of the Iron Work and Jealousies shewing the manner in which several portions of the Iron Work are put together.



these except in length, being nine feet one-fifth of an inch long: twelve are required for each end of the building.

Figs. 22 and 23. Plans of the angle joists.

There are sixteen of these joists required for one end of a floor, eight of which have their bevel ends reversed; the lengths of each are different, as will be seen in *plate* 3.

Figs. 24 and 25. Plan and section of the main shoe.

This shoe rests on the wall of the building, and receives one end of the main and one end of the gallery girder, and assists in forming a transverse tie throughout the building, as in *plate* 1, *fig.* 1.

Figs. 26, 27, and 28. Plan, elevation, and section of the end gallery shoe.

Two of these shoes are required for each end of the upper or ground floor of the gallery.

Figs. 29 and 30. Plans of the angle shoes.

These two shoes are required for each end of the upper or ground floor of the gallery.

Plate 5. Plans, sections, and elevation of parts of the frame-work, showing the jalousies, staircases, and cornices.

Figs. 1, 2, 3, and 4. Elevation and plan of part of staircase.

A staircase consists of the following parts: 2 strings, 17 risers, 17 tension bars, 1 shoe.

The head of the staircase rests against the upper girder, and the feet of the strings in a shoe.

Figs. 5 and 6. Plan and elevation of a jalousie.

Figs. 7, 8, and 9, show the manner in which the several parts of the iron work are to be put together.

List of the Iron Work for a Barrack of 200 Men, with Two Floors; showing the Number of Pieces required, together with the Weight of each Piece.

Name of Iron Work.	Number of each Piece.	Weight in Pounds of each Piece.
Lower columns	44 } 4 }	690
Do. angle do.		
Upper columns	41 } 4 }	450
Do. angle do.		
Lengths of cornices for upper and lower galleries	68	350
Short angle do. do.	8	386

List of the Iron Work for a Barrack—*continued.*

Name of Iron Work.	Number of each Piece.	Weight in Pounds of each Piece.
Long angle cornices for upper and lower galleries	8	462
End cornices	12	350
Lengths of roof cornices for the galleries	34	390
Short angle do.	4	400
Long do. do.	4	504
End roof cornices	6	390
Pieces of gutter	76	88
Angle do.	4	56
End do.	20	88
Sets of handrailing complete	68	161
Angle do.	4	201½
End do.	20	161
Main girders	32	2068
Gallery girders	80	537
Short angle do.	8	498
Long do. do.	8	1138
Square plates for the heads of the lower girders to pass through	48	36
Main joists	102	276
Gallery joists	272	232
Sets of angle joists (8 in each set)	8	922
End joists	48	232
Main shoes	64	102
End gallery shoes	8	75
Angle do. do.	8	100
Doors complete	20	1300
Jalousies do.	60	884
Gallery tie bars	32	113
Centre pieces of do.	16	104
Angle do. do.	4	104
End do. do.	12	94
King posts (with bolts and nuts)	16	50
Circular plates (with fore-lock keys.) N. B. Thirty-two of these plates are to have the opening in the centre, 3 in. by 1⅝, to correspond with the centre pieces of tie bar.	48	27
Staircases complete	2	1993
Heads of water-pipes	4	56
Angle do.	4	68
Lengths of water-pipe	32	90
Ventilators	80	190
12 cwt. iron cement.		

32 bolts and nuts, 1 inch by 7½ for king posts; 192 bolts and nuts, ¾ inch by 5½, for the principal rafters, bressummers, and roof cornices, with nuts; 576 tap screws, ½ inch by 3½ inches.

2nd Class. The second class of buildings are to be provided with a basement and one or two floors; but the breadth is reduced to sixteen feet, and the gallery is intended only for the front and two ends of the building. It does not appear that any occasion has hitherto arisen for adopting this class, or that there exists any details of the proposed frame-work.

The details of the frame-work of the first class were intrusted to Captain Brandreth, Royal Engineers, who availed himself of the advantage afforded him in superintending the castings of a building for ~~Bermuda,~~ Bahamas designed by Colonel Fanshawe, Royal Engineers. The designs are essentially the same; but there are some slight differences in the strength of the sections, and mode of connexion, that may be noticed. The sections for Sir Charles Smith's plans were reduced in consequence of experiments made at the foundery, on the strength of the former sections; and the present sections may be taken as of maximum strength, for the particular purpose to which the building is appropriated.

The ordinary mode of connecting the several parts of iron work is by flanches and bolts; in the present instance, the frame-work is put together with dovetails and pivot joints, further secured with lead. By this simple mode, bolts and bolt-holes (which require nice adjustment), and the danger of any irregular pressure on flanches, are avoided. The junction of wrought and cast iron is also avoided, a circumstance of importance in a climate where the union of the two conditions of iron occasions greater liability to the decay of each, than when they are used separately.

In tropical climates generally, and more particularly in the West Indies, the following circumstances are of importance in the construction of dwelling-houses and hospitals.

1. The extreme of heat and moisture.
2. The sudden alternation of calm weather with high winds; and
3. Hurricanes.

The most important local peculiarities are,

1. The neighbourhood of marshes.
2. Elevated open positions.

The influence of heat is much modified by the galleries that surround the main part of the building, and scarcely any houses in the tropics are constructed without this precaution.

The galleries with the jalousies to the windows are of importance in the rainy season; without them the windows are obliged to be closed during the heavy rains, that sweep at a low angle against the buildings, and thus the air is excluded. The fans of the jalousies are so constructed as to admit the air and exclude the rain; they are also of advantage in regulating the admission of air during the frequent high winds. It is of the utmost importance, when any building is designed, to consider the means of guarding against the hurricanes

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that constantly occur in the West Indies. The subject is now undergoing investigation by Lieutenant-Colonel Reid, of the Royal Engineers, from which valuable results are anticipated. To persons unacquainted with the tropics, it is hardly possible to convey a notion of the effects of a hurricane on buildings apparently of the strongest construction. It may be sufficient to observe at present, that the mode of securing the roof is the great desideratum. Two buildings constructed on Sir Charles Smith's plan, have been subjected to the action of severe hurricanes, and the result, it is believed, has been favourable to the general principle of the plan. One of these buildings, an hospital, is erected in an elevated and open position in the island of Antigua. It has a basement and two floors, and the height from the foundation to the ridge is about 40 feet, and the site about 400 feet above the sea. With the exception of some slight damage to the roof, the building sustained the shock.

The second building, also an hospital, is constructed in an open plain at Barbadoes, but of no great elevation above the sea; and consists only of a basement and one floor, the height of the whole building being about 30 feet. It is reported to have sustained no material injury from the hurricane, while almost all the buildings in the neighbourhood were destroyed, or severely damaged. There were indeed some indications, close to the wall plates, that the roof might have given way had the storm continued, but they were not however sufficient to require repair.

The roof of the body of the building might probably be constructed of sufficient strength to resist the hurricane: the slates are liable to be stripped off; and therefore it may be desirable to apply some covering that would present a perfectly even surface throughout to the action of the wind. If metal were adopted, the rooms immediately under the roof should have a ceiling.

The roof over the open gallery is the principal defect in the building, and the one of the most importance, in considering the effect of the wind. On reference to the section of the building, (*fig.* 3) it would appear that this roof may be subjected to the action of the wind, under circumstances the most unfavourable; inasmuch as, when compressed between the roof and the wall, the wind would act on the former in the direction of its least resistance. It is also to be apprehended that, when so acted on, it would be a powerful lever, tending to injure the the main wall of the building. This evil might in some measure be remedied, by applying a ceiling to the gallery.

It is proposed to resume this subject on a future occasion: in the mean time

it is recommended for consideration, whether the system of ties, by means of the frame-work of the floors, may not be advantageously adopted in the roofs of the main building and galleries; so that a uniform and effective resistance to the wind may be obtained throughout the building.

It not unfrequently occurs in the West Indies, that barracks, and even hospitals, are of necessity built in the neighbourhood of marshes; and notwithstanding the precautions of raising the ground floor four or five feet, surrounding the building with galleries, and the ordinary modes of ventilation, the influence of the malaria has been very fatal.

Dr. Arthur, of the army medical staff, recommended the application of wire gauze to prevent or mitigate the effect of the marsh malaria.

There are several medical authorities that favour this officer's suggestion: cases are adduced where the interposition of a screen of vegetation between the building and the marsh, has averted the noxious effluvia and prevented disease, while buildings in the neighbourhood without such protection have suffered severely. Vegetable screens are not encouraged, because by their decay and decomposition they generate marsh miasma.

The well-known fact of travellers protecting themselves with veils, while crossing the Pontine marshes, may be quoted; and the late Sir W. Franklin, M. D. mentioned, that in Sicily the sentries, when posted near marshes, occasionally wore a sort of wire helmet.

In 1827 the crew of a ship of war* lying in English harbour, Antigua, was attacked with the disease, generated by a marsh in its immediate neighbourhood. The windward ports were kept open during the early stage of the sickness; but as this admitted too much air for the patients, they were covered with bunting, and the disease is stated to have mitigated from that period, and soon altogether to have subsided. These facts may be sufficient to warrant a trial of this precaution, although there may not exist any probable theory for its success.

The properties of miasmata have hitherto escaped detection of analysis; but it is generally assumed that vegetable substances, in the slow decomposition which takes place in them in the process of putrefaction, give out inflammable gases. It may be that the wire gauze simply sifts, or as it were dilutes the body of malaria, and renders its operation on the human frame less obnoxious, when introduced in particles through the net-work, than in a compact stream through the open window.

* The Magnificent, Captain Mansell.

The cast iron frames of the windows, now in use in the West Indies, would admit of gauze being introduced, by merely removing the fans of the jalousies. Of the several specimens of wire gauze, the best for this purpose is that which has the mesh, or interstice, 1-24th of an inch square. The wire should be of copper, as most of the buildings in the West Indies are exposed to the immediate action of the sea air.

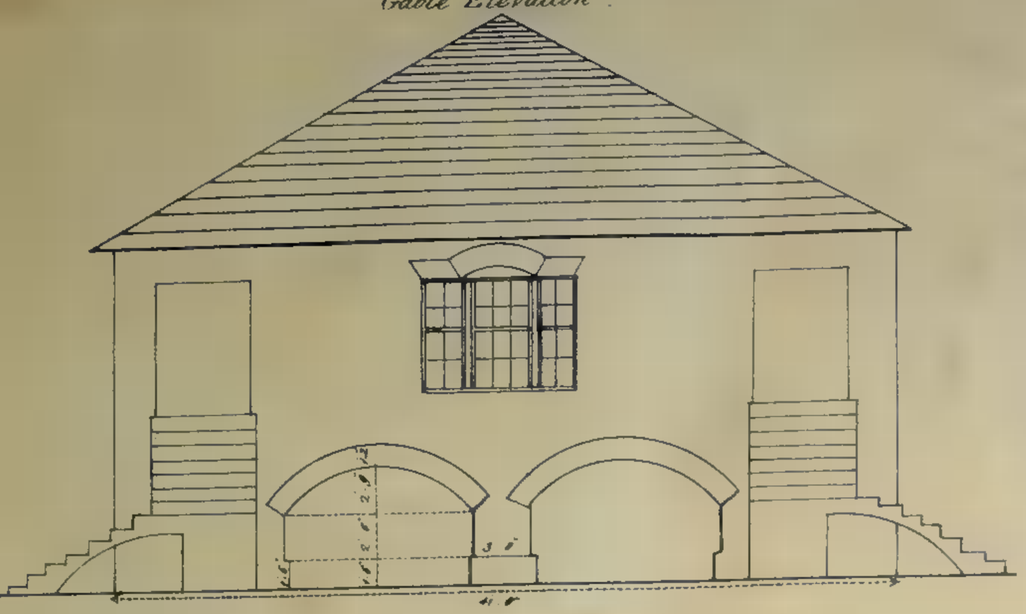
Copper wire is about 3*s*. per square foot; iron wire about 2*s*. ditto. The necessity of constantly renewing the latter, would more than counterbalance the difference in the prime cost of the two metals; and if it were attempted to preserve the iron with paint, the meshes would be liable to be filled up.

It is probable another advantage may be found in adopting the gauze blinds. Many of the barracks in the West Indies are on elevated positions, and exposed to a strong trade wind. The soldiers are in the habit of closing the jalousies on the windward side, and thus interrupting the free circulation of air. The gauze would secure a more moderate and equable diffusion of wind throughout the building.

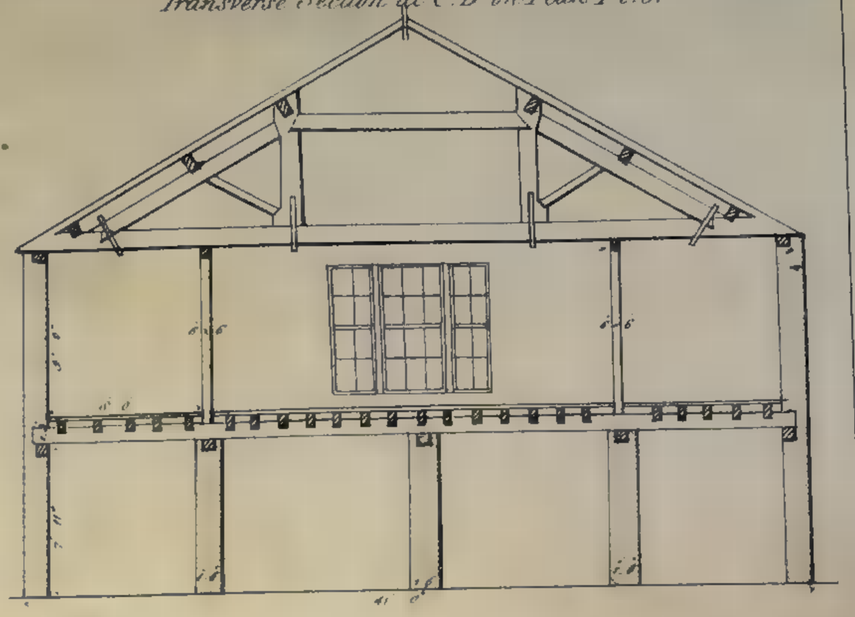
H. R. BRANDRETH,

Captain, Royal Engineers.

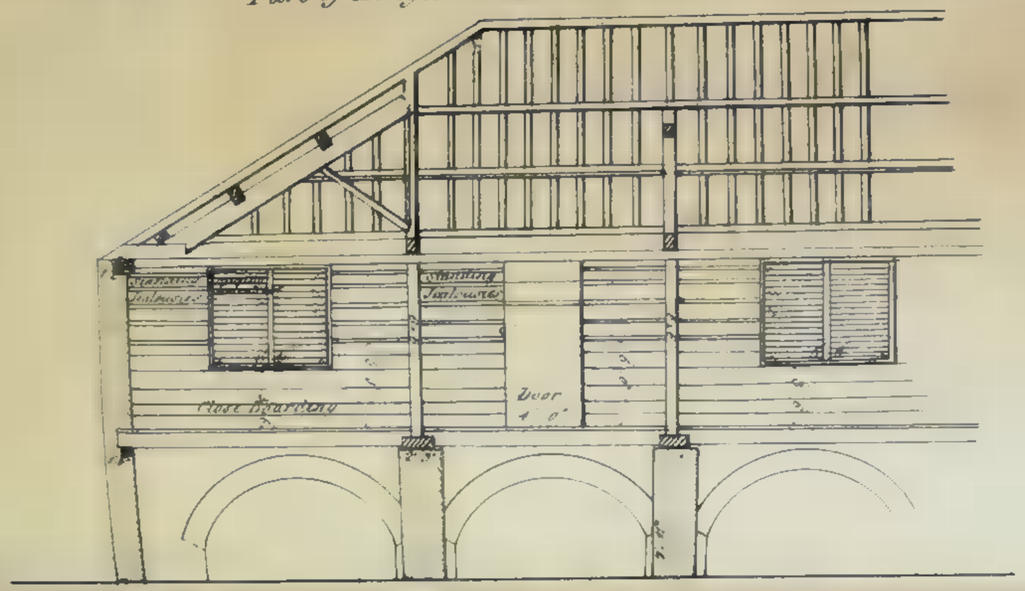
Gable Elevation.



Transverse Section at C.D on Plan Pl:6.



Part of Longitudinal Section at A B on Plan Pl:6.



Scale Ten Feet to One Inch

XX.—*Description of Barracks at Lucea, in Jamaica.*

PLATES 6 and 7 show plans, elevations, and sections of a barrack at Lucea, in the island of Jamaica, proposed by Captain West, Royal Engineers. In this barrack the gallery or verandah, which is in general an exterior appendage to the building, is included within it; the main walls being placed far enough apart to allow of a space for a gallery being left between them and the partitions which form the walls of the rooms. These partitions are only carried up a certain height, and the whole space between the floor, roof, and walls, is left free for the circulation of air.

The objection to the common mode of building verandahs is, that they afford no protection or shelter to the building itself; in consequence in the rainy season, or generally in bad weather, the windward side of the verandah is useless as a place of resort, and the circulation of air in the barrack itself is impeded, as the jalousies to windward are necessarily partially shut, to prevent the beating in of the rain. In the Lucea barrack, on the contrary, the verandah itself, being protected by jalousies, may always be left open to a certain extent to windward; for although the rain may beat through into the gallery, yet it will not incommode the soldiers in their rooms, and a constant circulation and change of air is thus kept up, which in those climates is essential to health. The addition of some sort of ventilation at the ridge, which was suggested by Lieutenant Renwick, Royal Engineers, would be a great improvement to the plan, as allowing the escape of the heated air, and establishing thus an upward current, which would carry off all the impurities which must exist where any number of men are crowded together in a narrow space.

The principal objection to this plan of building is, that it increases the span of the roof by the width of two galleries; these, however, need not be made near so wide as is generally the case with exterior galleries, and the benefit is too great to be put in competition with a very trifling increase of expense.

This description of building has been adopted by the planters in some of the West India islands, and is less liable to injury from hurricanes than buildings with external galleries.

W. D.

XXI. — *Memorandum with reference to the accompanying Sketches of the Officers' Barracks erected at George Town, Demerara. By* Mr. Cuming, *Clerk of Works, R. E. D., Cork.*

The trenches for the foundations were excavated to a depth of about 8 inches; and where found softer than usual, or where intersected by old trenches, deeper excavations were made, filled in with broken stones, and grouted.

Sleepers of Wallaba timber, 6 by 6 inches, and from 2 to 3 inches apart, were laid transversely, the spaces between them filled with broken stones, and grouted; 2 inch Greenheart planks were spiked to the timbers; the pillars built thereon, and the ground formed around them, to the depth of about 2 inches.

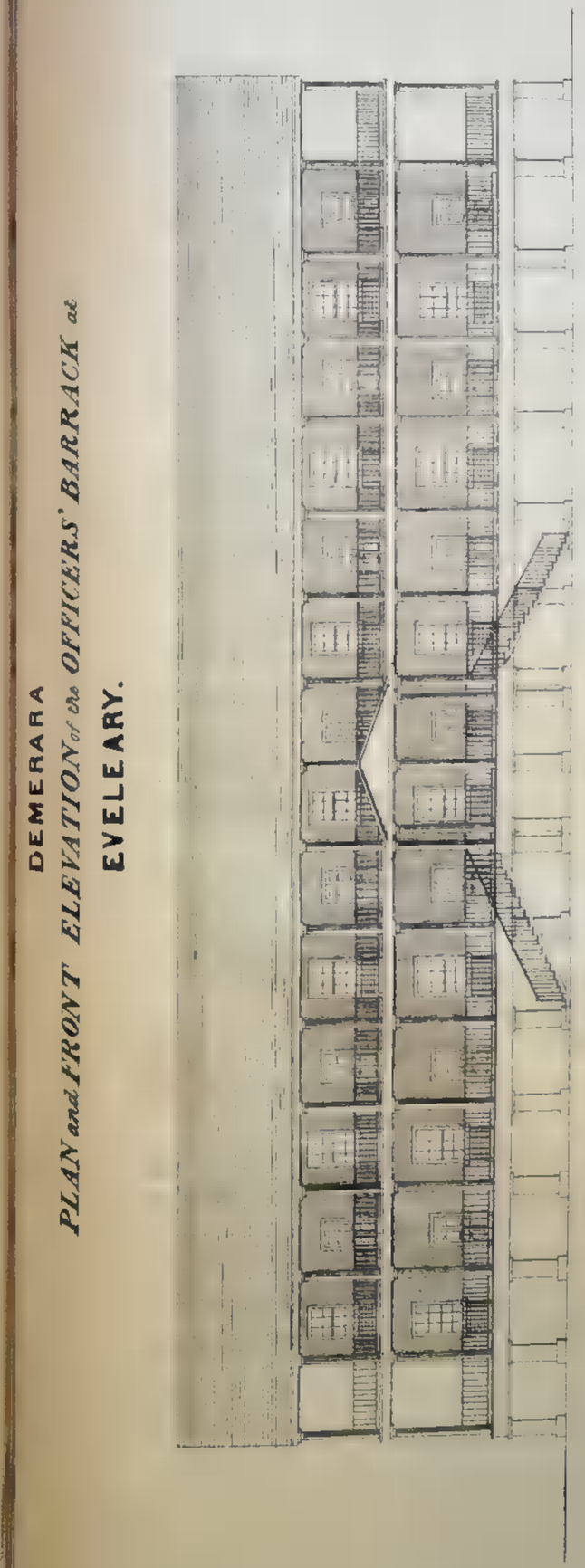
The pillars are 8 feet in height, built of malm pavior-bricks, having two off-sets, the first of two courses, and the second of four courses in height, and capped with Yorkshire paving-stones, neatly squared; the mortar was composed of slaked lime from England, and sand obtained from the beach in front of the Ordnance lands, in the proportion of about 20 bushels of sand to 1 hogshead, or about 24 bushes of slaked lime; the outer faces of the brick-work being pointed with Harwich cement.

The framing of the buildings is of hardwood, of the undermentioned scantlings, viz.:

Sills 8 inches by 8, quoin posts 7 by 7, braces 7 by 7, uprights 7 by 5, turned columns about 13 inches in diameter, and interties 8 by 6. Braces (2nd floor) 6 inches by 6, uprights (2nd floor) 6 by 5, plates 6 by 4, turned columns about 10 inches in diameter, and plates over them 7 by 4. Door-heads 7 inches and 6 by 4, window-heads 7 and 6 by 3, and window-sills 11 and 10 by 3, and 1 inch boarding (Cabacally) wrought, and rebated.

Partition uprights 4 inches by 4 on 1st floor, and 4 by 3 2nd floor; cross-rails 4 by 2, boarded upright with three-quarter ploughed and tongued Determa.

The roof timbers are of hardwood, of the following scantlings: viz. cantilevers over galleries 8 inches by 3, tie beams 10 by 3, king posts 12 and 6 by 3 in shafts, struts or braces 5 by 3, principal rafters 9 and 8 by 3, purlins 5 by 3, pole plates 5 by 3, rafters 4 by 3: boarded in part with hardwood, and partly

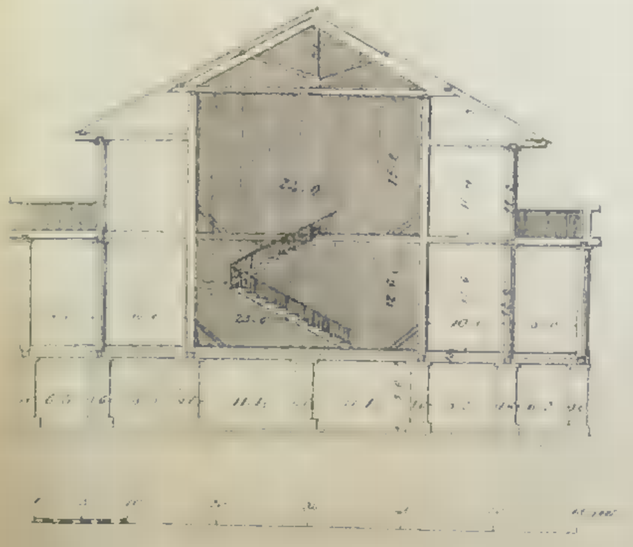


DEMERARA

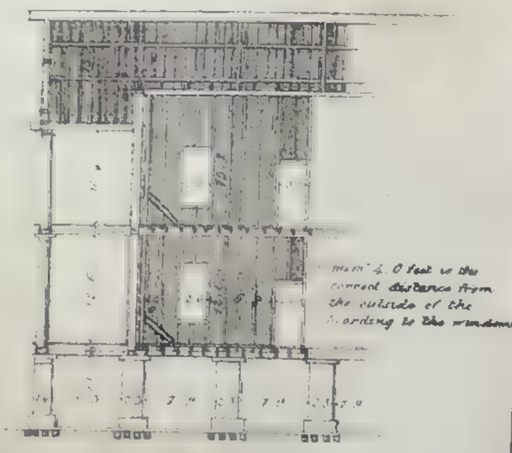
END ELEVATION and SECTIONS of the OFFICERS' BARRACKS at

EVELEARY.

Section on the Line a b



Section on the Line c. d.



Scale 5 feet to 1 inch.

with red and yellow pine, slated with Welsh duchess slates, laid with composition nails, and the ridges covered with 6 lbs. milled sheet lead.

The floors (internal) are of $1\frac{1}{2}$ inch pitch pine, ploughed and tongued, and laid on hardwood joists 9 in. by 3; the gallery, or virandah floors, of $1\frac{1}{2}$ hardwood, on joists 9 by 3, reduced to 8 by 3 at the ends, to form an inclination towards the front for carrying off the water, and protected in front by a hardwood facia, covered with a hardwood planceer, rounded on the outer edge.

The doors are of $1\frac{1}{2}$ inch American pine, wrought, framed, and moulded on both sides, hung with 3 inch iron butt hinges, fitted with 7 inch iron-rimmed locks, with brass furniture, hardwood linings, plain pilasters, plinths and blocks on the outside.

The folding doors of field-officers' quarters and in mess-room are also of American pine, 2 inches thick, wrought, framed, and moulded on both sides, hung with $3\frac{1}{2}$ inch brass butt hinges, fitted with mortise locks and brass bolts.

The jalousied doors to the gable doorways are of $1\frac{1}{4}$ inch Determa, hung with 3 inch iron butt hinges, and fitted with spring latches: all the windows are fitted with $1\frac{7}{8}$ inch astragal and hollow sashes, double hung, with brass pullies, patent cord, and lead weights, with brass spring fasteners, and of course glazed, with hardwood pulley stiles, outer facings, pilasters, blocks and plinths, and inside linings of pine, with the exception of the windows in the gables, of which two in each are fitted with sliding jalousies; sliding jalousies are also provided underneath the sashes to all the windows in the rooms.

The ceilings are of 1 inch pine, wrought one side, and nailed to hardwood joists, 8 inches by 2, fixed parallel to the tie-beams, so as to form additional ties to the buildings.

The gables are framed of hardwood; viz. uprights 5 inches by 3, window heads 5 by 3, and sills 9 by 3, and boarded up with 1 inch Cabacally, wrought and rebated, and the spaces over the end galleries are provided with floors, so as to be adapted to store-rooms, if required.

The entrance steps are of $1\frac{1}{2}$ inch hardwood, with 1 inch risers, 3 inch strings, balustrades $1\frac{1}{4}$ square, handrails 4 inches by 4, turned newels 4 by 4, framed into sills 6 by 6, laid on Yorkshire stone paving and brick-work, built on foundations of 2 inch Greenheart planks, on Wallaba sleepers 6 by 6.

The inner staircases are of hardwood; viz. $1\frac{1}{4}$ inch steps, 1 inch risers, 2 inch strings, balustrades $1\frac{1}{2}$ square, handrails 3 inches by 3, turned newels 4 by 4, joists of landings 6 by 3, trimmers 6 by 4, and $1\frac{1}{2}$ inch flooring.

All the wood and iron work is painted thrice in oil. The roofs are provided with tin gutters, lead cistern heads and lead descending pipes, which convey the rain water into cast iron tanks, erected at short distances from the buildings.

Both ranges and both floors of each building are alike, with this exception, that in one wing the mess-room and ante-room occupy the whole space from the gable to the inner staircase.

RICHARD CUMING,

Clerk of Works, Engineer Department.

Cork, 16th Dec. 1837.

XXII.—*Captain Sandham's Mode of Curing or Improving Smoky Chimneys; with Remarks also on Count Rumford's System, &c. Communicated by Colonel* PASLEY.

PRELIMINARY REMARKS.—I had been for many years incredulous as to the possibility of curing very smoky chimneys, from several circumstances. First, in Malta, where I occupied a small garden house in 1803 and 1804, of which the upper room smoked dreadfully; I altered the fire-place, according to Count Rumford's plan, and placed on the top of the flue a double tin covering of ▪ complex form, having none of the external and internal openings opposite to each other; and after these changes, which appeared to cure it effectually, I invited all the officers of the Royal Artillery and Engineers, then my messmates, to come and see my improvement; but, previously to their arrival, the wind having shifted, they found, to their amusement and to my disappointment, that the room which I brought them to admire was filled with a dense atmosphere of smoke, which drove us all out in a moment. From this circumstance I was led to believe that Rumfordizing a chimney was of little use, unles the flue were raised as high as all the adjacent objects, which in the situation alluded to could not conveniently be done, my then quarter being situated opposite to a re-entering angle of a very high cavalier bastion, at a moderate distance, but yet too great to connect the flue of the chimney with the walls of that work.

Since that time, I have never known fire-places* that smoked, perfectly cured by any alteration, though they have been occasionally improved. Mr. Hiort's new chimneys, which I noticed in my lithographed 'Essay on Practical Architecture,' written in 1826, which were then extensively tried by many architects of

* Mr. Hiort made each of his flues cylindrical, and of uniform diameters, from the chimney breast upwards, which he inclosed in a square flue of larger dimensions. The former alone was open at top for the passage of the smoke. The spaces between the two, at the angles of the square being hermetically sealed against any communication with the air, either above or below, contained quiescent air, not subject to alterations of temperature, and warmed by the internal flue which communicated with the fire. He attached great importance to this point. If Mr. Hiort's system were equally effective, it has one disadvantage as compared with Count Rumford's or Captain Sandham's systems, inasmuch as it cannot conveniently be applied to old chimneys.

the metropolis, have, though an improvement, since been disused, because as he had a double flue, of which the internal one was built with chimney bricks made on purpose, of a very ingenious construction, the expense was too great; and I am informed that the smoking was not in all cases absolutely prevented. Several attempts on Brompton barracks, Chatham, having either failed, or only palliated the evil, I was naturally doubtful as to the success of any expedient suggested for this purpose. The room occupied by me as an office, in particular, always smoked in westerly winds to such a degree, that it was absolutely uninhabitable. The endeavours of an intelligent brother officer, who once occupied the room, and of an experienced master bricklayer, who both attempted to cure it some years before, by altering the fire-place, had not proved effectual; and an expedient afterwards tried by me, which consisted in introducing air from the outside by an aperture under the grate, to increase the draught, having also failed, I gave it up as incurable, and burned coke, to avoid the nuisance of smoke, for two winters past, which appearing to have injured my health, I determined recently, as a last resource, to raise the flue by a metal pipe about fifteen feet long, to be placed on the top of the chimney-shaft, which would probably have cured the evil, because the chimney of the room immediately below on the ground floor of the same house did not smoke in any wind. At this period Captain Sandham offered his services to cure it, which he said he felt confident that he could do, from having often succeeded at Corfu; and although I was myself very doubtful as to the result, I acceded to his request to allow him to try it, considering that at all events it would be an experiment on an interesting point of practical architecture. Accordingly he tried it first in a rough manner by a few bricks and a piece of iron plate, which to my surprise having succeeded perfectly, I shall annex a description of the method pursued by him, which he says is not entirely original, as the idea occurred to him first at Corfu, where the chimneys are of a very extraordinary construction, the flues being much larger even at the bottom than is usual in England, and diverging to a still larger size as they ascend, like immense square funnels, which are covered at top by a regular roof of pantiles laid dry, to allow the smoke to pass. These enormous chimneys usually smoked, until the fire-places were altered in a variety of ways, by which alterations some of them were cured, and some improved, whilst others were not. By observing all these alterations with attention, and combining parts of various fire-places, the best of which had been altered by Mr. Mennie, an

intelligent overseer of works in the Engineer Department, Captain Sandham was led to adopt the system which forms the subject of this paper.

Having since referred to Count Rumford's Essays, which I had not looked into for many years, and which Captain Sandham had never seen, until I put them into his hand, I found that there was a great similarity, excepting in *one principle only*, advanced by the Count, from which the Captain's practice differs; and it may also be observed, that there are many of the most modern register and other stoves, used for open fire-places in this country, in which parts of Captain Sandham's system may be traced; as in fact I believe, that the makers of the best of these stoves have been indebted to Count Rumford's Essays for some portion at least of their respective constructions; but taking it as a whole, I consider Captain Sandham's system, if a compilation or combination of the various parts of former fire-places, or stoves, to be a most excellent one; for since the fire-place in my office has been *Sandhamized*, as we now term it, the chimney has never smoked at all, except when the grate has been overloaded, and part of the chimney even choked up with a mass of fresh coals, on removing which the smoking immediately ceased.

Count Rumford's System.—Considering the similarity before mentioned between the system laid down in Count Rumford's work, published in 1796, and that recently adopted by Captain Sandham, it will be convenient first to describe the former, as explained in the author's fourth 'Essay on Chimney Fire-places.'

Count Rumford recommended, that fire-places (which in his time were usually of the old rectangular form, no further altered from the opening left by the bricklayers, than by having a grate put into the lower part of each,) should all have their sides altered by coving them, so as to form angles of 135 degrees with the back of the fire-place, or of forty-five degrees with the front of the grate; and being of opinion that the throat of the chimney, as he calls it, was much too large, he recommended contracting it to the width of four inches, by which alterations, instead of the former large rectangular opening, it becomes a much smaller trapezoidal one, having the front side considerably longer than the back, and the depth or distance between these two parallel sides only four inches, as aforesaid. To effect these alterations, it is necessary not only to build two new sides of the covered form proposed, but also a new back for the fire-place, which he proposes to do with bricks or fire-stone. These three new walls are only to be carried up six inches higher than the bottom of the mantel-piece, at which level he directs that they shall be terminated abruptly.

Count Rumford's improvements are explained in the annexed figures, of which *fig.* 1 is the plan of a common fire-place, with the grate omitted for the sake of clearness: *fig.* 2 is the plan of the same *Rumfordized;* and *fig.* 3 is the section of the latter, also without the grate.

Fig. 1.

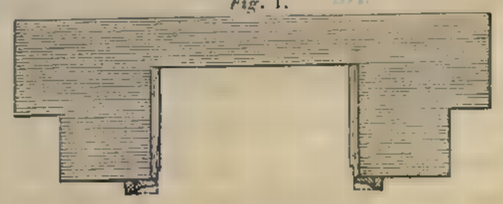


Fig. 2.

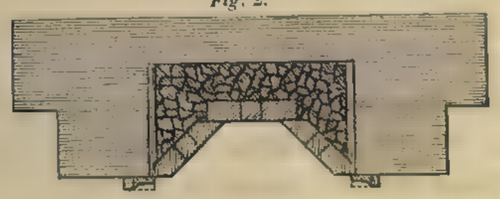
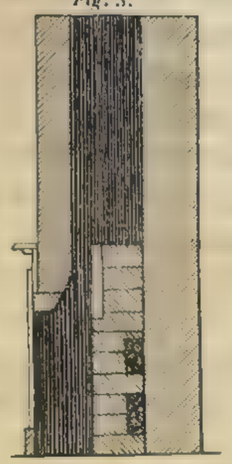


Fig. 3.



In this last figure, it will be observed, that the inside of the bottom of the mantel-piece is rounded, which he considers useful for guiding up the smoke. The termination of the throat of the chimney, which, after being contracted, opens abruptly into the full size of the original flue, will also be remarked in this figure. The Count recommended particularly, in respect to this point, that the throat of the chimney, after being contracted below, should not be nicely rounded or sloped above, so as to open out gradually into the larger space that has been mentioned. He objects to this nice finishing, which gives to the upper part of the throat of the chimney a form that he calls *trumpet-mouthed;* because he thinks that occasional puffs of smoke, driven down into the flue by eddy winds, are guided by these gentle curves into the room, whereas the abrupt termination of the upper part of the throat of the chimney proposed by him, arrests these puffs of smoke in their descent, and drives them back again.

As there is not sufficient room in four inches to allow a chimney-sweep to pass for that purpose, he proposes to have a vertical piece of fire-stone, or a large tile, ten or eleven inches square, set up dry in a sort of rebate in the back of the fire-place, which is to be occasionally removed, in order to permit a chimney-sweeper's boy to go up the flue, and which must be replaced, after the chimney shall have been swept.

Considering that it is the rarefaction of the air by the heat of the fire, that

causes it to ascend, and carry up the smoke along with it, and that the hotter the air becomes, the more powerful will this action be, Count Rumford states, that the distance between the mantel-piece and the grate should be diminished as much as possible, without running into some contrary inconvenience: and as he considers that the natural tendency of the warm air and smoke is to rise vertically upwards, he states, that it is absolutely necessary that the throat of the chimney shall be perpendicularly over the fire; and he conceives that this object will be sufficiently attained by making the back of the grate to coincide with that of the new throat of the chimney, when laid out according to the above rule. But in the event of a grate being so large that this arrangement would throw it too far forward into the room, he states that it may be set back into a sort of hemispherical niche, made with fire-stone, of which *fig.* 4 is a section.

Fig. 4.

In the lower Library Room of the Royal Society at Somerset House, the fire-place was altered according to Count Rumford's directions, and it is considered to be one of the best in the house. The grate is set down much lower than usual, which heats the air in the lower part of the room better than the common position; and in consequence of this the bottom of the chimney-breast has been brought down lower than its original position, by filling in beneath the mantel-piece, as Count Rumford recommends in his Treatise, when any of that part of the chimney is too high.

It is in the above-mentioned principle that smoke *must* ascend vertically upwards, and therefore that the throat of the chimney *must necessarily* be placed vertically over the grate, that Count Rumford's practice chiefly differs from Captain Sandham's, which shall next be described.

Captain Sandham's System.—I before mentioned that Captain Sandham completely cured the fire-place of my office, which smoked so much as to be uninhabitable in westerly winds before he altered it. In consequence of this unexpected success, four other fire-places in my own quarter, which is opposite to the office, two in the quarter which he himself occupies as adjutant, and two in the quarter of the Superintendent of the Junior Officers' Course of Surveying and of Practical Astronomy, were also *Sandhamized.* All the apartments in the officers' quarters in Brompton barracks are fitted up with grates of one and the same pattern, excepting in the four principal apartments of each of the field-officers' quarters, in which there are register-stoves, also of one

pattern. Some of these grates had been set a few inches further back than others, so that the position of all was not exactly, though nearly alike, and some of them were filled in, both at the sides and behind the grate, more than others: hence, as Captain Sandham had formed his plan from observation and trials, and had not reduced it to a regular system, like Count Rumford, he did not attempt to correct the position of any of those grates, but rather modified his own dimensions to suit them. Hence also the several fire-places altered according to his plan, of which one of those in my quarter had previously been fitted with a register-stove, whilst all the others had the grates alluded to, were not all alike; and these little differences served as experiments, though not intended for that purpose, which enabled us to ascertain what was the most perfect mode of improving a chimney according to Captain Sandham's method; so that we are now able to lay down precise rules for the necessary alterations, which was not the case when he began.

My office fire-place, which was the first he attempted to improve, and two fire-places in the attic story in my quarter, having all been altered according to the same plan, and having succeeded perfectly, I shall describe the office fire-place as a pattern that may be followed with a certainty of success.

In this fire-place the grate, which was nearly 14 inches wide in front, 9 inches wide in rear, and about 1 foot deep from front to rear, was set nearly 6 inches in from the face of the chimney-jambs. The original state of the fire-place, when Captain Sandham undertook to cure it, is represented in plan by *fig.* 5, in which

Fig. 5.

Fig. 6.

the original opening left by the bricklayer between the chimney-jambs is represented, whilst the grate and its hobs, and the filling in behind it, are also shown. *Fig.* 6 is a section of the same, showing the grate and filling in behind it, with the throat of the chimney and part of the flue, in which state it always smoked in westerly winds, however moderate, and in strong westerly gales dreadfully.

Captain Sandham reduced the width of the back of the fire-place to 9 inches by coving the sides more than they had been before, which new covings formed an angle of about 42 degrees at the back. The back of the grate extended about 4 inches further into a recess beyond these covings, and the throat of the chimney, which was placed nearly vertically over it, was 9 inches in width, corresponding with the width of the new back of the fire-place.

Fig. 7 represents this arrangement in plan, which, as compared with *fig.* 5, shows the alteration; and so far as the plan alone of the fire-place is concerned, it does not appear to differ much from Count Rumford's system: but in *fig.* 8, which is the elevation, and in *fig.* 9, which is the section of the same, it will be observed, that not only the sides, but the upper part of the back of the fire-place also, are coved on Captain Sandham's system. Below this top coving is the mouth of the chimney, as it may be termed, being a rectangular opening 9 inches wide and 6 inches high, above the level of the hobs of the grate, into which the smoke from the fire first enters as it rises, in a direction almost horizontal, and then changing its course, ascends vertically by the throat of the chimney into the flue. The appearance of this aperture, viewed from the room, is shown in *figure* 8. In some other fire-places its width has been reduced to 8 inches.

Fig. 7.

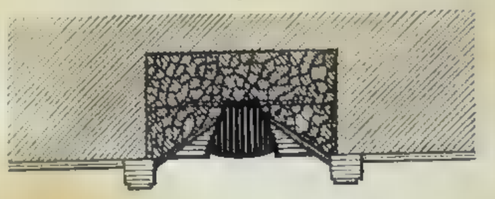
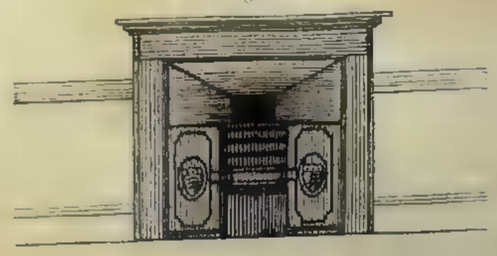


Fig. 9.

Fig. 8.



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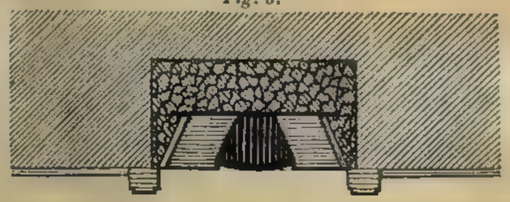

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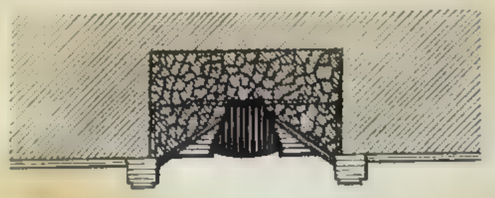


Fig. 9.

Fig. 8.

The smoke ascending through the mouth and throat of the chimney, may be

compared to water flowing through a strait, leading suddenly into a sort of gulf or much larger channel; for in this fire-place, after raising the sides and back, within and behind the side covings and grate, a little higher than the mouth of the chimney, the filling in behind the side covings, as well as behind the position of the back of the grate, terminated abruptly, without being rounded off: thus, whilst the side covings were not quite so deeply recessed as Count Rumford's, every thing else agreed with his rules, excepting that the Count had no top coving.

In *Sandhamizing* our fire-places in Brompton barracks, we formed our covings with paving-tiles a foot square, cut to the required splays; and one of these tiles over the centre of the throat of the chimney was made to take out, having been placed dry, and the joints towards the room not flushed, but only pointed with cement, so that it is moveable when the chimney requires sweeping.

In consequence of the too forward position of the grate in the only fire-place in my quarter, fitted with a register-stove that was Sandhamized, the whole of this stove came in front of the new mouth of the fire-place, as shown on plan in *fig.* 10, and on section in *fig.* 11.

Fig. 10.

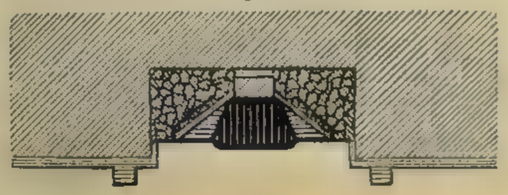
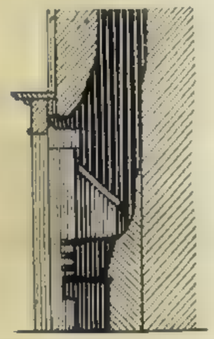


Fig. 11.



Hence no part of the fire, when lighted, was immediately under the throat of the chimney, which proved so far disadvantageous, that this fire-place still emitted puffs of smoke in moderate winds, after being Sandhamized. If we had to do the thing over again, we should therefore take this register-stove entirely out, and set it 4 inches further back, in order to enable part of the fire to stand immediately under the throat of the chimney. Another point was not attended to in this fire-place, the original filling in behind the back of the grate of the register-stove having been allowed to remain; in consequence of which this chimney, though decidedly much improved, still smokes in violent easterly gales of wind.

I have already given one instance of the importance of Count Rumford's rule, "that after reducing the throat of a chimney the work should terminate abruptly a little above that level." Several other proofs of the necessity of this maxim occurred in the course of our alterations; for the bricklayers in two or three instances thought proper, of their own accord, to slope up both the back and sides, above the throats of our Sandhamized fire-places, in order to make a neater finish, and also from a natural desire to make it stronger; and thus they produced that sort of trumpet-mouth above the throat of the chimney which the Count reprobated; in consequence of which all those fire-places still continued to smoke a little: but on altering them once more, by removing all the extra filling in, so as to restore abruptly the large rectangular opening of the original brick-work, forming a sort of gulf immediately above the throat of the chimney, this evil was remedied; and none of these chimneys now smoke, even in the most violent gales of unfavourable wind, excepting by emitting small puffs occasionally on lighting the fire, which cease when it burns clear.

Of all the fire-places that have been Sandhamized properly, with due attention to the position of the grate and to the above maxim, only one still smokes in westerly winds, which is that of a servant's room in the attic story, over my office; and as the office itself has been completely cured, the difference must be ascribed to the flue in the attic story being much shorter, which always causes a tendency to smoke.

As compared with Count Rumford's system, I conceive that the top coving of Captain Sandham's improved fire-place is a great advantage, inasmuch as it brings the throat of the chimney nearer to the fire, without the inconvenience of allowing too much of the heated air to pass up the flue; instead of which it throws out much more heat into the room than when the back is upright, as every one acknowledges, who has been in the same rooms, before and after the fire-places were Sandhamized.

General Remarks on other Causes by which Chimneys are affected.

As Brompton barracks are situated on high ground, very commanding towards the west, north, and north-east, and not commanded by any adjacent objects on other sides, the opinion I adopted in Malta, that buildings in this position would not be liable to smoke, is incorrect; but I have remarked, that in

violent winds those parts of the barracks which are exposed to the direct fury of the gale, do not smoke so much as those which are comparatively sheltered from it, the latter being subject, no doubt, to eddy winds, from which the former are free. Sometimes rooms in my quarter, in which there is no fire, have the smoke from the chimney of another adjacent apartment driven down into them by eddy winds.

In the United Service Library at this place, a small building having only two rooms, the fire-places of which, at different ends of the building, are scarcely forty feet apart, one never smoked at all, whilst the other was so bad, that the officers who subscribed to that institution found it necessary to use an iron stove placed in the middle of the former room, the flue pipes from which were led up and guided into the chimney of the other. In a room on the ground-floor of the field-officers' quarter, occupied by me, one apartment, fitted with a register-stove, often smoked violently in easterly winds; but after opening a door into another room it has scarcely ever smoked, this door being cut through the same wall as the fire-place itself, on the side most distant from the window. In its present state, this room has one entrance-door from the passage, the fire-place and the new door opposite to this, a large window on the left, and a large door of communication into another room on the right. In the room above, on the contrary, which had only one door opposite to the fire-place, and one window, and which smoked in certain winds, but moderately, the opening of a new door into an adjacent room caused it to smoke a great deal more; and on again closing up this door the smoking abated. I have also known chimneys caused to smoke by putting on cement chimney-pots only 7 inches square in the clear at top, which proved to be too small an opening; for on removing these, and putting on larger pots, the smoking ceased.

In respect to chimney-caps, or cowls, I will not deny their utility; but I have never seen any which, to my own personal knowledge, completely cured a smoky chimney; and Count Rumford observes, that in ninety-nine cases out of one hundred, the evil lies at the bottom of the chimney, and may be cured by altering the fire-place, and therefore he is of opinion that chimney-caps are of inferior importance; but he mentions one sort, which he says he has known to do good, for the description of which I refer to his own work, as I have never myself seen such a one used: but from the favourable impression which I now have of the judiciousness of the Count's system, which he could not have

digested without accurate observation, guided by great sagacity, I am inclined to think well of every thing advanced by him upon the subject of chimneys. On looking back to the failure of my own Rumfordized chimney in Malta, I feel persuaded, that the chief cause of my disappointment was the extreme shortness of the flue, for I suppose the distance between the chimney-breast and the top of the flue could not have been more than ten feet.

Improved Chimneys in the Anchorsmiths' Shop at Chatham Dock-yard, constructed by Mr. Perkins.

Captain Sandham has not yet tried his system for curing the chimneys of smoky kitchens, to which, from the space required for the cooking apparatus, it may be more difficult to apply it; but the remarkable improvement in the fire-place of the anchorsmiths' shop in her Majesty's dock-yard at Chatham, which was effected many years ago by the late Mr. Perkins, then master builder, nearly on the same principle recently adopted by Captain Sandham, gives reason to hope that it may do good even in kitchens. The large rectangular hearths, on which the anchorsmiths made the fires for heating their irons, were formerly entirely covered with very large hoods, into which the smoke was expected to rise vertically, and be discharged at the top of the flues or chimney-shafts, of which these hoods formed the bottom, instead of which the greater part of the smoke spread over and filled that large room. The improvement made by Mr. Perkins consisted in removing these hoods entirely; instead of which he built flues at the back of the several hearths, each having a rectangular opening into it a little higher than the hearth, to which it bears the same relation as the opening in the back of Captain Sandham's fire-place does to the grate. For the larger fires required for the heaviest work, these openings are about 18 inches high, and about 4 feet 6 inches wide, whilst the depth of the flue, measured from front to rear, is 2 feet in the clear; and there is only one flue of this sort in each chimney-shaft. For the smaller fires, suited to light work, there are two flues to every shaft, the entrance into which measures about 15 inches high and about 2 feet broad, the depth of the flue at this part being 13 or 14 inches. The fires in the anchorsmiths' shop, made upon the several hearths, are all by this arrangement placed entirely in front of, and not under, any part of their respective flues; and yet the smoke, instead of rising vertically, and filling the whole of this

spacious workshop, rushes apparently out of its natural direction into the openings at the bottom of the flue. This ingenious alteration proved so extremely beneficial, by diminishing the quantity of smoke, that the anchorsmiths addressed a letter of thanks to Mr. Perkins, signed by the whole of them, in which they declared, that they were convinced that it might be the means of prolonging their lives.

C. W. PASLEY,
Colonel, Royal Engineers.

Royal Engineer Establishment, Chatham,
Feb. 15th, 1838.

XXIII.—*Notes on Concrete. By Lieutenant* DENISON, *Royal Engineers.*

SINCE the publication of the first volume of 'Professional Papers,' circumstances have caused me to pay particular attention to the application that has been made of late years of concrete, or artificial stone, to the various purposes of construction; and I shall now briefly state the experiments that I have made or witnessed on this subject, and the conclusions that may be fairly deduced from the results of these experiments.

The first experiment was made with the view of ascertaining whether a mass of concrete, made with Aberthaw lime, would resist the chemical action of water: for this purpose a small block, which had been prepared for nearly two years, was immersed for some time in distilled water, and upon applying the proper test to the water, it was found to have combined with a portion of the lime in the block. Having mentioned this circumstance to Sir M. Faraday, he suggested, that it was probable the block contained a quantity of lime in an uncombined state; and recommended that it should be placed in a running stream for some time, in order to wash it thoroughly: this was accordingly done, by suspending the block for two months under a hulk in the river, after which, having again soaked it in distilled water for a week, hardly any trace of lime could be detected in the water by the application of the most delicate tests. This experiment then appears to prove that concrete, composed of proper materials (hydraulic lime and gravel,) does not suffer by the chemical action of water.

Experiment No. 2 was made in order to ascertain the strength of a block of concrete 2 ft. 6 long, 1 ft. 6 broad, and 1 foot deep, which had been made for two years, and would have been used as a stretcher in the river-wall at Woolwich. A shackle was placed round the centre of the block, and two others at the extremities, at a distance of 11½ inches each from the centre; a force being applied to the two end shackles by means of the hydraulic press, the block broke in the centre, under a strain of 4 tons 11 cwt. I did not prosecute the experiment upon the strength of this material any further, having sent down some blocks to Colonel Pasley, R. E., who was investigating the same subject, and the results of whose experiments are as follows:

Three stones, each 3 feet long, 18 inches wide, and 15 inches deep, were

supported upon props 27 inches apart; weights being then applied to the centre of each, the first broke with 6285 lbs., the second with 5141 lbs., and the third with 2930 lbs. This last had probably some flaw; taking therefore the mean of the two first only, the result will be 5713 lbs.

A piece of York paving, $7\frac{1}{2}$ inches deep, 13 inches wide, and the same distance (27 inches) between the supports, broke with a weight of 13,512 lbs. The value of the constant S, in these two cases, deduced from the formula $S=\frac{lW}{4bd^2}$, will be for concrete 9·5, and for York paving 124·7, being about in the proportion of 1 to 13.

The experiments I have had the opportunity of witnessing, and which offer by far the most instructive results, have been the practical application of concrete to the construction of river-walls at Woolwich and Chatham: in both these instances M. Ranger's patent concrete has been used. In one instance, at Woolwich, it has been applied in mass, the wall having been constructed in the same manner as the Brighton sea-wall, described by Colonel Reid, in vol. i.: in both the other instances at Woolwich and Chatham, the concrete was formed into blocks, which were allowed ample time to set and harden before they were built into the face of the wall.

At Woolwich the river-wall is for the most part founded upon piles; its height above the piles is about 24 feet, the thickness at bottom 9 feet, at top 5 feet, with a slope or batter in front of 3 feet in 22: the face of this wall is composed of the above-mentioned blocks, which are laid in cement, in courses 1 ft. 6 in height, the headers and stretchers in the course being each 2 ft. 6 long, the former having a bed of 2 feet, while the latter have only 1 foot; behind the facing the rough concrete is thrown in to complete the thickness of the wall and counter-forts. Both the blocks and the rough concrete are composed of lime and gravel, in the proportion of 1 to 7, and brought to the proper consistance with boiling water; but the blocks are, or ought to be, made with Aberthaw lime, while Dorking lime is used for the rest of the work. The blocks are cast in moulds, and are submitted to pressure while setting: a coating of finer stuff is given to the face for the sake of appearance. The whole of the wall is built by tide work, and in the lower part therefore the backing of rough concrete has hardly time to set before it is covered by the tide; the water, however, in this instance, appears to affect the surface of the mass only, the interior, at the depth of a few inches, being generally speaking dry, and of a moderate degree of hardness when examined after the retirement of the tide.

During the summer the action of the water from day to day upon the facing of the river-wall was not perceptible; the surface still remained moderately hard; occasionally portions of the fine facing separated from the rest of the block, owing, it was said, sometimes to want of care in the original construction, sometimes to injuries caused by boats or vessels striking the wall: in these cases, however, a new facing of cement was applied, and before the winter the general appearance of the wall was to a certain extent satisfactory.

During the hard frost, however, evidences of failure began to show themselves; and as soon as the thaw allowed a thorough inspection of the face of the wall to be made, it was found that hardly a single block had escaped without some damage; in many instances the whole face had peeled off to the depth of half an inch; and at one spot, where a drain discharged itself into the river from a height of about six or eight feet, the back action of the water after its fall had worn away the lower courses to the depth of some inches: these were the evidences of the action of frost and water combined upon the best constructed wall at Woolwich. At Chatham they were of the same character, but the damage done to the wall was much greater.

The portion of river-wall at Woolwich, which was built with rough concrete, had been severely injured by the common action of the water before the frost; and the latter has only caused the destruction of the face to proceed with greater rapidity. Since the frost I have examined the walls of a school near Blackheath, which was built with concrete some years ago: I found that at the ground line, where the drip of the water had acted, the concrete was soft, and yielded easily to any force applied, while the walls above were very fairly hard, and seemed to have stood very well.

These then are the facts I have to lay before my brother Officers; and I think they afford sufficient grounds for asserting, that in climates like ours, in situations exposed to the alternate action of water and air, concrete cannot be advantageously used as a building material, the apparent economy, caused by the cheapness of the material employed, being more than compensated for by the frequency of repairs. From the circumstance that at Chatham some of the blocks remain to a certain extent uninjured, whilst others close to them, and exposed to exactly the same action, are completely decomposed, one would be tempted to infer, that proper caution had not been used in the selection of the lime of which the latter were composed; and that had Aberthaw lime been used

throughout, the damage would not have been near so great: but even in this case, although the frost might not have produced so much effect upon the work, and should concrete be considered perfectly impervious to chemical action, yet the want of tenacity, or of power to resist a very trifling force, renders it peculiarly inapplicable to situations where, as in wharf-walls, it will be exposed to damage from the collision of vessels and floating bodies, in addition to the constant mechanical action of the water: where, however, it is protected from these causes of destruction, as in foundations, its value is unquestionable; and even in the backing of retaining-walls, revetements, &c., it may in many cases be advantageously applied, taking care to allow it time to set before any great pressure is thrown upon the wall. The specific gravity of concrete is from 120 to 130, about the same as that of brick-work.

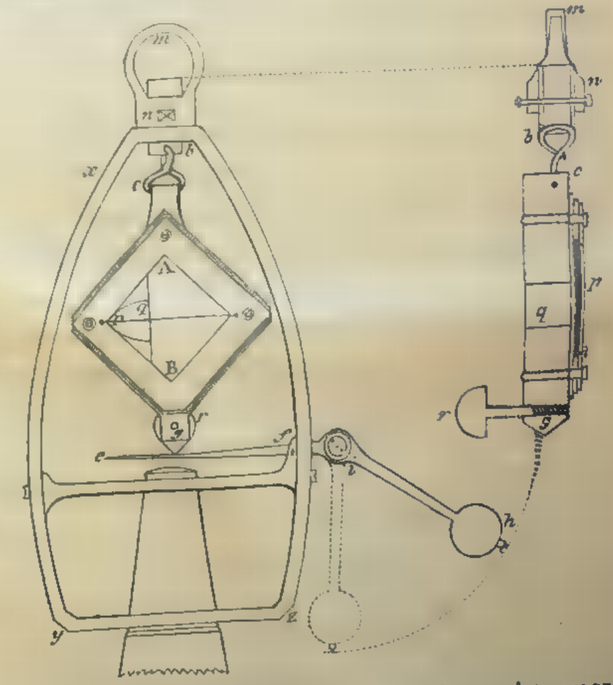
W. DENISON,
Lieutenant, Royal Engineers.

XXIV.—*Extract of a Paper on a Reflecting Level, invented by Lieut.-Colonel* BUREL, *du Corps du Génie.* (*From the 'Mémorial du Génie.'*) *Translated by Lieutenant* YOLLAND, *Royal Engineers.*

REFLECTING levels are constructed on the principle, that the eye sees its image reflected in a vertical mirror, at an equally great distance behind the mirror which it is itself distant in front of it; and that the line joining the centre of the eye and the centre of its image, is always horizontal and perpendicular to the plane of the mirror.

The advantages which the Committee of Engineers for the Encouragement of Science have recognized in these instruments are—

1st. Their simplicity of execution and rectification.
2nd. The great length of their line of sight.
3rd. Their compactness and stability.
4th. The facility of using them.



DESCRIPTION.—The common reflecting level consists merely of a small mirror, *A B*, of 1 inch square, fixed against a vertical plate of metal, weighing

from $\frac{3}{4}$ to $1\frac{1}{2}$ lb., and suspended to a ring, *m n*, by a buckle of steel wire, elongated and twisted on its vertical axis so as to form two eye-let holes, *b c*, perpendicular to each other, which permits it to hang freely, but prevents it from turning round on its axis of suspension, *b q*.

When it is necessary to rectify this instrument, or to be very exact in taking levels, it should be suspended in a frame-work, *x y z t*, fixed on the common tripod used by surveyors.

In this state a plate of metal, *e f*, pressing from below against the point *g*, by the action of the counterpoise *h*, serves as a curb to diminish and check the oscillations; it also prevents, by its resistance, the effects of the wind.

If the instrument has already been rectified, it may be used in a much more expeditious though less exact method, by detaching it from the frame-work, as in *fig.* 2, and holding it at arm's length at the same height as the eye, by means of the ring, *m n*.

Rectification.—The only rectification required is that of rendering the mirror perfectly vertical, so that the line of sight may be horizontal. The following is one of the most simple methods:

1. Having suspended the instrument in its frame-work, fixed on the ordinary tripod at from forty to fifty yards distant from a wall, place yourself fronting the instrument and wall, and direct the line of sight from your eye to its image (which a silk thread, *p*, cuts in the centre) in the mirror, and bring, by a gradual movement of the head, the image on the edge of the mirror, so as to be enabled to see at the same time through the opening, *p q*, in the framed plate of metal, the wall behind it, and note on the latter the exact point where the line of sight prolonged cuts it.

2. Turn the instrument half a revolution in its frame, and place yourself between the instrument and wall, with your back to the latter: observe where the line from your eye to its image cuts the reflected view of that part of the wall directly over or under the first mark, and make a second mark on the wall.

3. Assume a point on the wall intermediate between the first and second, and displace the centre of gravity of the instrument by turning the screw *r*, until the line from the centre of the eye to its image in the mirror, intersected by the thread, coincides with the assumed point reflected: the adjustment will be complete.

This adjustment will be rendered still more accurate if the point of vision be marked on the ball of the eye and on its image by a small brilliant circle, the

centre of which will be more easily distinguished by looking through a small oblong slit cut in a card, and held at from nine to thirteen feet distant from the mirror, which will make the length of the line of sight from eighteen to twenty-six feet. At this distance the thread appears only as a line without thickness.

During the preceding operations the curb, *e f*, has checked the oscillations or repressed them from the commencement, without having power to render nugatory the spontaneous verticality of the pendulum; its light pressure of from 30 to 120 grains, regulated according to pleasure, being little in proportion to the weight of the pendulum, it acts at the most distant points from the axis of suspension, and its direction passes directly through the centre of oscillation of the smaller body.

It may be remarked, that during this adjustment the least error in verticality is seen at once, and with a precision double that of the plummet: in fact, every angle produced by reflection appears double what it actually is; that is to say, if the pendulum have an error of one minute, the angle reflected will appear to be two minutes, and two or three slight taps on the curb with the finger gives to the instrument liberty to resume its verticality.

Spirit Level compared with the Reflecting Level.

The water or spirit level is uncertain, troublesome in confined places and rugged ground. Its form renders it sensible to the least wind or sudden jerk; its fall may even destroy it, and render null many of the preceding observations. One person is always required to carry it; and continual attention must be directed to preserve the level; and the line of sight seldom or ever exceeds three feet.

The reflecting level, on the contrary, from its size is not affected by the wind or being accidentally touched. Its fall does it no injury: it is easily carried, and may be used without a stand by hanging it from a tree, at a window, or in a word without any trouble whatever. Little space is required for using it, as the length of the line of sight is optional, and may be as much as twenty-six feet. Again, it may be made of the commonest materials, such as hardwood, if brass, silver, or platinum cannot be obtained.

If it be true that the reflecting level has so many advantages over the water or spirit level, when they are both placed on the ordinary tripod or stand, its superiority will be still more displayed in such hasty observations as may be necessary to an army in the field, where it will be sufficient to hold it at arm's

length, and equal correctness will be obtained as with the spirit level requiring more care, and occupying more time. Why is this so? We know that a pendulum will oscillate a long time when suspended from a fixed point; but if it be attached to another which also oscillates in proportion to its length, the oscillations of the pendulum checked by those of the support are soon shortened and annihilated: any one may verify this fact by suspending a weight from the finger, and swaying it gently as it oscillates.

To level in this manner, the instrument must be held at arm's length, and at the same height as the eye. Take advantage of one of its short moments of repose, which are nearly periodical, and make the observation, which, though furtive, will be much more correct than would be expected, since in repeating it immediately afterwards by a second and third *coup d'œil*, it will be seen that these last results differ very slightly from the first.

This precision may be augmented by suspending the instrument from an arm at the end of a short staff, set up to the requisite height.

In this manner observations may be taken in every direction without a stand or choice of station, only stopping to make the necessary note; and it is most convenient in levelling gently undulating ground, or in filling up the details between two horizontal contours.

Thus in taking the height of several hills, varying from 190 to 260 feet of elevation, which had been previously levelled, it was found that the greatest errors did not exceed 6 inches; so much for its correctness: and for celerity, upwards of 60 acres have been levelled in a single day by horizontal contours distant only one yard from each other, and with the assistance of a single aid to carry the staff.

XXV.—*Memorandum on Paving Stables. By Captain* Alderson, *Royal Engineers.*

Constant repairs being required to the pebble paving of the stables at the cavalry barracks at this station (Brighton), and the usual mode of repair adopted, viz. relaying the pebbles in screened gravel, being found ineffectual, the following mode was resorted to with complete success.

The paving down the centre of the whole length of the stall, two feet in width, was taken up, and the ground excavated six inches deep throughout; a few half sovereigns, or six inch Purbeck stone pitchers, which happened to be at hand, were then placed on the part generally occupied by the fore and hind feet of the horse; the remainder was then filled in with concrete* to within one inch of the required level, and whilst the concrete was in a semi-fluid state, the pebble paving was relaid and rammed into it level with the half sovereigns, when the whole was grouted: it set in a couple of days, but was not occupied for ten. The pebble stones, thus firmly fixed in a matrix of concrete, are immoveable, and found to answer completely. The trial was on a 16-stall stable. It has been constantly occupied since done without any complaint.

Laying paving or concrete foundation is of course not new, it is provided for in the schedules; but paving on it when in a semi-fluid state is so, as far as I know.

Though this appears to me the best mode that can be resorted to in pebble paving, I am of opinion that six inch yellow pine blocks Kyanized, placed on their ends diamond-wise on a bed of concrete, will be found both more economical as a paving, and infinitely better for the horses' feet and legs. I hope in a short time to be able to describe the best mode of laying these blocks: I am now trying different modes. I believe it is generally adopted in Russia, though I do not know either their dimensions or the mode adopted in laying them. My present idea is, that by taking off the lower angles at the four corners with an adze, so as to make the lower end octagonal, they may be laid like the pebbles in the concrete as a matrix.

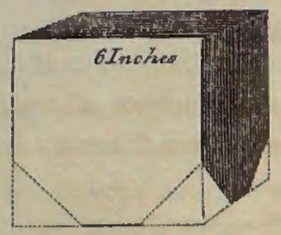
* The concrete was made in the manner usually adopted here in the sea-wall, as described by Lieut.-Colonel Reid, but without the pug-mill; viz.

Part 1. Water lime slaked on the spot; 2. Fine sea sand, or gravel; 3. Shingle.

The two latter ingredients are obtained from the beach; the former underneath, and the latter on the surface.

Extract from Engineer Officers' Diary at Brighton, dated 3rd Jan. 1838:

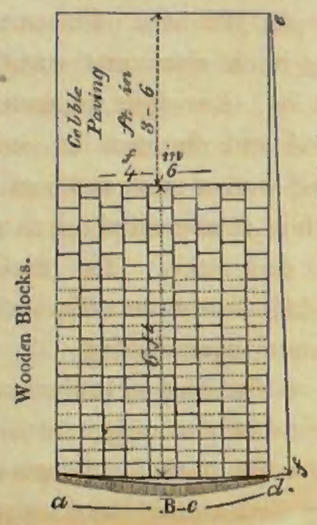
"The wooden blocks for the pavement of the stalls in the stables are formed thus:—The upper surface being a square, and the lower an octagon, by taking off the lower corners with an axe; the blocks are then set in concrete from 3 to 4 inches in depth; they are set with mortar, and the pavement is grouted when set.



"The transverse grooves have answered most completely. They need not, I think, be made more than three or four feet from the rear upwards; that is as far as it is ever likely the hind legs of the horse may tand, the fore legs being on the cobble pavement thus:

"The dotted lines show the grooves, which are also made at the joints, making them every 3 inches. The course under the bail in each stall, and not shown, would be flat like the centre course at the stall, and this will make up the five feet to each stall.

Head of the Stall.



A to *B* ½ inch fall.
d to *c* ½ inch fall.
Centre course flat, *e* to *f*, 4 inches; present floor may be reduced to 2, or even 1 inch.

"In consequence of the report that the stall laid with 6 inch wooden blocks was found slippery, I was of opinion that transverse grooves, half an inch wide and deep, and 3 inches apart, would remove this complaint without destroying the principle. These grooves have been made, and by mistake longitudinal ones also: this I consider unnecessary; but several were done in the present instance before I was aware of it.

"The instrument by which this groove was made may be termed a bird's-mouth gouge, being a common gouge ground down.

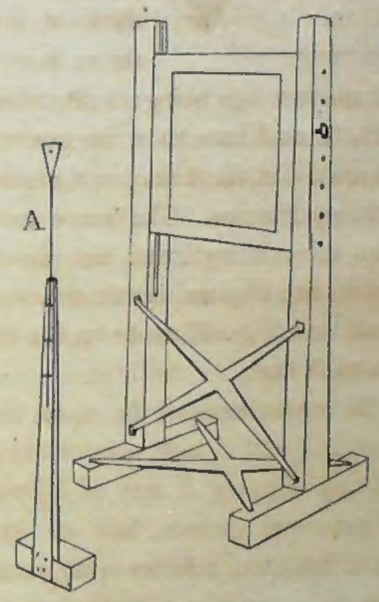
"I consider the 4 inch fall may be reduced one-half. The floor, it appears to me, will endure as long as the barrack, without once requiring repair: the size of the blocks may be regulated so as to accommodate the timber of which they are made; nor is it absolutely necessary that all the blocks be of the same size, so that *all* in the *same* course have one dimension, besides the depth the same: the depth should however, I think, never be less than 6 inches."

R. ALDERSON,
Captain, Royal Engineers.

Brighton, 11th Sept. 1837.

XXVI.—*A Method of taking Perspective Outlines from Nature.* By Samuel B. Howlett, Esq., *Chief Draftsman, Ordnance.*

So simple is the method by which I occasionally take outlines from models, machinery, statuary, buildings, or landscapes, that little is required besides a common tracing-glass and a piece of lithographic chalk. *Fig.* 1 represents the kind of glass used in the Engineer Department for copying plans, which may be raised, lowered, or sloped at pleasure. The only addition necessary is a sight and stand, such as shown at A. The sight is made of a stout piece of wire flattened at one end, and perforated with a small hole, and slides up and down in staples driven into a slip of wood nailed to a block. The block has three sharp points driven into the bottom, to keep the stand from shifting.



Having fixed on the spot which commands the best view of the object to be drawn, bring it into the glass in the most suitable manner, by first setting the glass in the proper direction, and then raising or lowering the sight, and adjusting the distance of the eye from the glass by moving the stand. The whole being adjusted, look through the hole, and, with the chalk finely pointed, trace the object upon the glass; and then to make the strokes of the chalk visible through paper, brush the glass over with a large hair pencil, lightly charged with any fine soft opaque powder, such as lamp black, which will make the finest lines appear as clear and sharp as if they had been printed from a copperplate. Now, by means of drawing-pins, fix a sheet of paper over the glass, and copy the work with a pencil or pen.

To bring the chalk to a fine point, it is necessary that the knife should have a chisel edge. The glass should be well polished.

There are many instruments contrived for the purpose of copying nature, of

which the camera lucida is perhaps the most elegant; but then the field of view, even when the stem is drawn out, is scarcely larger than one's hand.* By the means here pointed out, drawings measuring three feet by two may be conveniently made, supposing the glass to be that size; and such is the accuracy of which it is capable, that it is well adapted for taking the most exquisite miniature portrait of a bust.

There is, however, a strange professional prejudice against employing mechanical means in obtaining outlines from nature. It is represented that such assistance is only required by those who are ignorant of drawing: but this is an unfortunate error. The most accomplished draftsman must admit the inaccuracy of the eye in sketching; and it seems difficult to show why we should, in certain cases, be content with an approximate outline, when a perfect one can be easily obtained. If, for instance, the government were to order, as a grand national work, engravings to be made of the principal architectural antiquities which adorn this country, and which are fast perishing never to be restored, it certainly should be a question whether, instead of mere approximate hand sketches, persons well qualified for tracing should not be employed, to prepare perfect general outlines by mechanical means, to be afterwards completed by the genius of the first artists.

* One of the best methods of using the camera lucida is to lay aside the stand and use the prism only, the whole instrument is thus reduced to the size of one inch in length.—W. Reid.

83½, Pall Mall, 20th October, 1837.

J. Barrer, Printer, 9, Crane Court, Fleet Street, London.